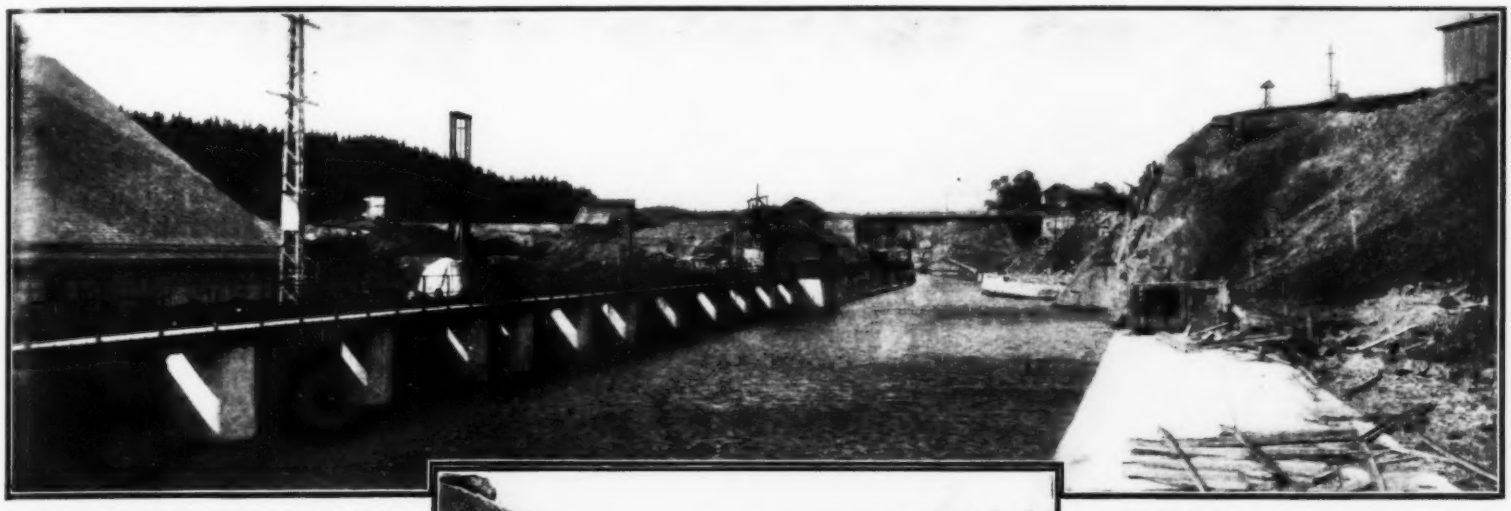
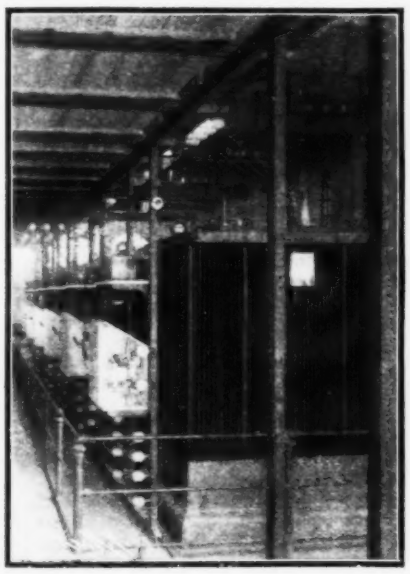
SCIENTIFIC AMERICAN SUPPLEMENT. No. 1534

Entered at the Post Office of New York, N. Y., as Second Class Matter. Copyright, 1905, by Munn & Co.

Scientific American established 1845.
Scientific American Supplement, Vol. LIX., No. 1534. NEW YORK, MAY 27, 1905. Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.



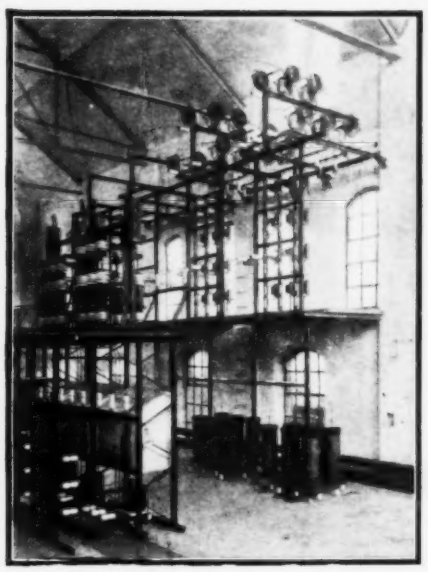
DISTRIBUTING BASIN AT END OF CANAL.



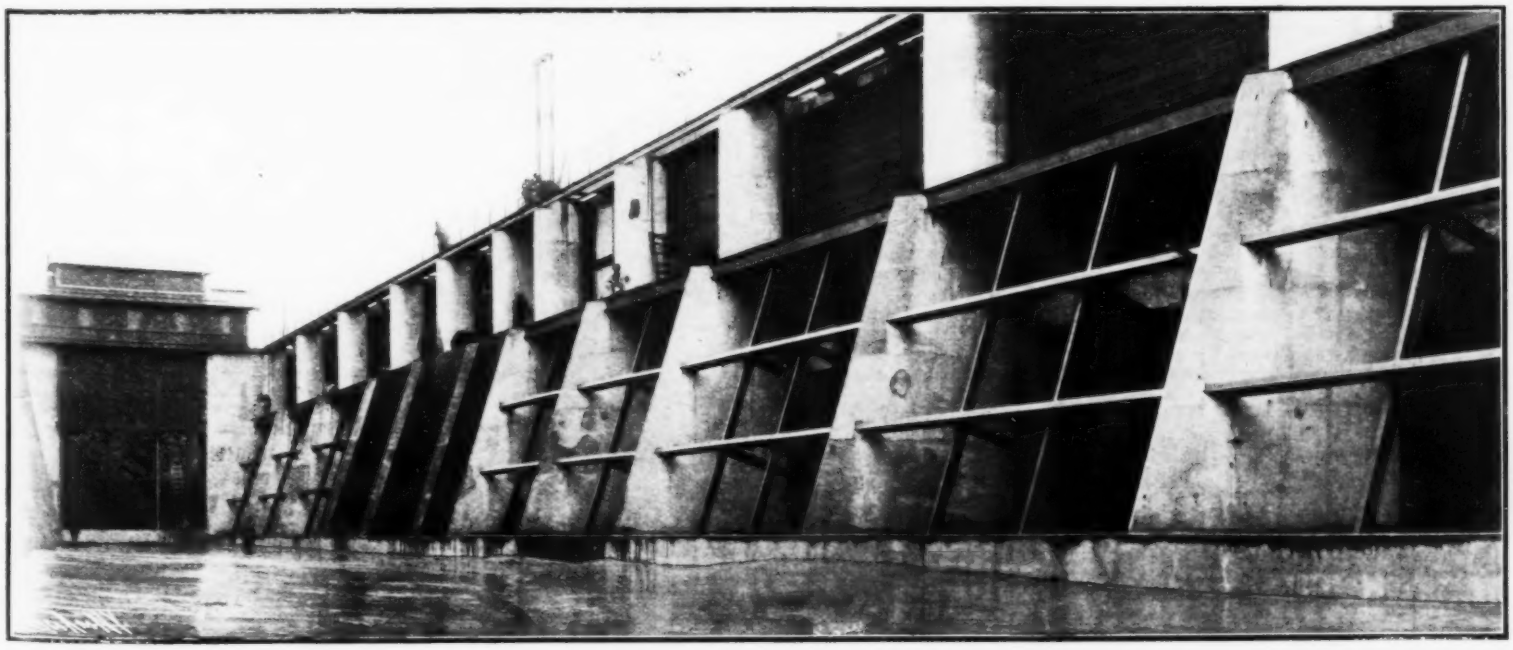
A GLIMPSE OF THE TRANSFORMER ROOM.

A STRETCH OF THE POWER RACE, SHOWING MASONRY EMBANKMENT THROUGH THE GLACIAL CLAY.

SHOWING SLUICES TO TURBINE INTAKES.



LIGHTNING ARRESTERS AND HIGH-TENSION SWITCHBOARD.



THE SLUICES TO TURBINE INTAKES OF POWER HOUSE.

THE GLOMMEN (NORWAY) HYDRAULIC POWER PLANT.

[Concluded from SUPPLEMENT No. 1533, page 24558.]

THE HYDRAULIC POWER WORKS ON THE RIVER GLOMMEN, NORWAY.

By the English Correspondent of SCIENTIFIC AMERICAN.

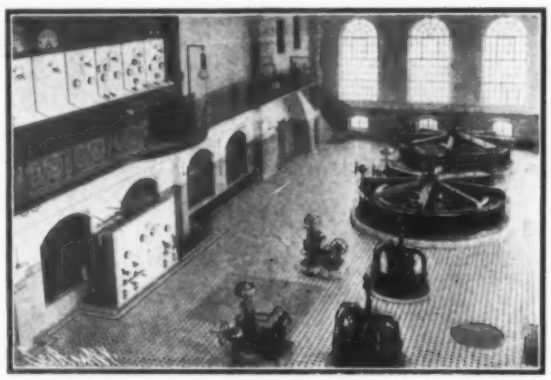
THE generating plant comprises two turbines of 3,000 horse-power each, driving alternating-current generators, and two turbines of 280 horse-power each, driving direct-current generators for exciting and lighting purposes. When the installation is complete, the plant will comprise three of the 280 horse-power, four 3,000 horse-power, and eight 5,000 horse-power turbines. The power house contains five pits, and the central one contains the two 280-horse-power direct-current generators, the turbines having been made by Mr. J. M. Voith, of Heidenheim am Brenz, who has also supplied one of the large 3,000-horse-power motors for the alternators, while the other was built by Messrs. Escher, Wyss & Co., of Zurich. This section of the plant is placed at the southern end of the power station. The inlets from the basin are each of the same height, 14 feet 9 inches, but the width varies according to the power of the motor to be driven. Thus, while the width for the 280-horse-power motor is 9.8 feet, it is 19.7 feet for the 3,000-horse-power, and 29.5 feet for the 5,000-horse-power turbines respectively. The rectangular form of the intakes is gradually changed to a circular form, so as to fit the shape of the pressure pipes to the turbines, while a ventilating shaft 20 inches in diameter is placed at the highest point of the inlet.

Owing to the wide fluctuations of the water level, ranging from 46 feet in winter to 64 feet in summer, with a corresponding difference in the tailrace of 39 feet between the two levels, the turbines are constructed upon the Francis principle, with central discharge through long tail pipes, and with vertical shafts and horizontal dynamos. The latter are placed nearly level with the floor of the machine room, at a height approximating 6 feet above the highest flood level in the river. The Voith 3,000-horse-power turbine is 6 feet in diameter, and the water entering the 10-foot intake pipes at a speed of 9 feet per second is accelerated during its passage through a spiral casing, which gradually reduces its dimensions until it attains a velocity of 20.8 feet per second at the guide ring buckets of the wheel. The tail water pipe is of conical shape, increasing in diameter downward, into a concrete siphon of continuously varying section, so that the speed of the water is thereby reduced to 3.8 feet per second at the outlet. The other, the Escher-Wyss 3,000-horse-power turbine, measures 7 feet in diameter. It is inclosed in a wrought-iron casing, which is centrally connected with the pressure pipe by means of a conical nose piece, containing a throttle valve 8 feet in diameter. There are twenty buckets to the wheel, with an outer concentric guide ring with twenty-two buckets. The admission is regulated by means of a slide ring between them, and the buckets on the guide ring are placed obliquely to each other, thereby giving larger openings at the top than at the bottom. The advantage of this arrangement is that a better regulation is possible than with the general parallel form, since when closing the sluice, the volume of water thereby cut off is greater at the beginning of the stroke. The main shafts of the two wheels are made of Siemens steel, and measure 25 feet and 27 feet in length, with a diameter of 12 inches. The total weight of the waterwheel shaft, revolving portions, and the field magnet wheel of the dynamos aggregates about 32 tons. Oil is forced down at a pressure of 15 atmospheres between the rubbing surfaces of the overhead bearings as a counterpoise, the weight of the moving parts being supported on an oil bed. At the normal speed of 150 revolutions per minute these wheels have an efficiency of approximately 75 per cent for an average head of 52 feet, and the efficiency is guaranteed not to drop below 72 per cent for a variation in the head of 6 feet in either direction at the same number of revolutions. The generators are three-phase alternators, with the armature rings fixed, and rotating field magnets. The latter have an outside diameter of 16.35 feet, and the former measure 16.4 feet internal diameter. The magnet wheel has 40 poles, makes 150 revolutions per minute, giving 50 cycles per second, and developing 2,500 kilowatts at 5,000 volts, with a maximum electric efficiency of 96 per cent. The exciter consumes from 16 to 24 kilowatts.

As the power is to be transmitted in some instances over great distances, for such transmission the primary current potential is raised to 20,000 volts by means of oil transformers, each of 950 kilowatts capacity. These are of a new and novel design. The iron core has the winding channeled with numerous passages. The resultant effect is that not only is there a distinct improvement in the insulation of the individual coils of the winding, as well as between the winding and the core, but highly efficient cooling is obtained.

For distribution over great distances there are five main lines, carried on posts 39 feet high with iron crossties.

At Stemmestad, about 55 miles from the Glommen power station, is the ultimate transformer station. At seven points along the line are placed at varying intervals substations. At each of these stations the transformer plant reduces the potential from 20,000 volts to 5,000 volts, and serves to supply the current direct to the destination at which the energy is required or for retransmission at the reduced voltage to other smaller substations, where the current is still further reduced to 150 volts.



THE FINISHED SECTION OF POWER HOUSE CONTAINING TWO 280-H.-P. TURBINES DRIVING D. C. GENERATORS AND TWO 3,000-H.-P. TURBINES DRIVING A. C. GENERATORS.

REINFORCED CONCRETE.*

UP to the last few years the use of concrete as a building material was chiefly confined to the construction of foundations, piers, reservoir dams, and similar purposes, in which the stresses to be met were almost entirely simple pressures. Indeed, even fifteen years ago many engineers looked askance on the use of concrete for arches, considering it for this purpose much inferior to brick. Much of the caution shown in extending the uses of this valuable material doubtless arose from the frequency with which concrete masonry exhibited unsightly cracks, due largely to the material being allowed to get too dry while hardening. At the same time, careful examination has shown that cracks of the same character are common in masonry of all kinds, but are unnoticed, because they follow the regular joints of the structure; whereas on the smooth uniform surface of concrete cracks of much less significance are immediately visible.

The plan of reinforcing the material with metal, of which several systems have been introduced during the last four years, has greatly extended the possible use of concrete; and it appears that in many cases a reinforced concrete bridge may compete, even in first cost, with a steel girder; while as regards upkeep, it has, of course, many advantages. Small bridge culverts of this material were extensively used by Russian engineers in building the Manchurian Railway. For openings of some 7-foot span, flat slabs of concrete reinforced with rails were used, the thickness being 8¼ inches. A similar system was used for spans up to 21 feet, the concrete, however, being thickened at the center as the span increased, the depth at this point being 2 feet 6¼ inches for the 21-foot span, and proportionately less for smaller openings. The thickness at the bearings was, however, the same in all cases—viz., 8¼ inches. The line was thrown over the spans as little as seven days after completion. The concrete consisted of one part cement, two sand, and five broken stone. The system in this case had great advantages, as stone for masonry was unobtainable, and could, moreover, only be used for arches, which would have necessitated the use of higher embankments than were required with the ferro-concrete used as described. Much larger spans have, of course, been built than those mentioned. One of 153-foot span, carrying four main-line tracks, has recently been built for the Lake Shore and Michigan Southern Railroad, while Mr. Edwin Thacker, M. Am. Soc. C.E., states he considers the system feasible for spans up to 500 feet, and has actually got out designs for a span of 300 feet, the cost comparing favorably with that of a steel bridge.

One great drawback to the extension of the system lies in the difficulty in proportioning structures thus built in a thoroughly rational manner. In the case of steel bridges, certain simple assumptions as to the elasticity and strength of the material suffice. These assumptions are doubtless not absolutely exact, but are sufficiently near the truth for practical purposes. The elastic properties of concrete are, however, very different from those of steel; Hooke's law is not even approximately correct, and, moreover, the material always takes a permanent set when first loaded. The true distribution of the stress and strain on a concrete beam is thus a much more complicated matter than it is in the case of a steel joist, in which it is permissible, within working limits of stress, to assume the accuracy of Hooke's law. The assumption generally made in the case of ferro-concrete is that plane sections of a concrete beam remain plane after bending. This postulate is, of course, that commonly made in proportioning steel-work; and in the latter case, stress being proportional to strain, the usual formula for the working strength of beams is readily deduced. In the case of concrete, however, the stress-strain curve is much more complex. Nevertheless, M. Considére has shown that by making experiments on concrete in simple tension and compression, and plotting the corresponding stress-strain curves, it is possible to deduce from these with fair accuracy the load-deflection curve of a ferro-concrete beam.

This method, though logical, leads, however, to no simple formula for the strength; and in applying this method the working load of any particular concrete beam would have to be deduced by the tedious process of scaling off the stress-strain curves at a number of points, and combining the results. A further question arises as to whether this stress-strain curve should be the initial stress-strain of the concrete, or that obtained after repeated loadings. Probably the latter is the best to choose, but in that case it by no means follows that the metal reinforcement is free from initial stresses when the load is applied to the beam; and if the metal is subject to initial stress, it is obvious that similar ones must exist in the concrete. In fact, M. Considére has shown that this is necessarily the case in any circumstances, since, if the concrete is allowed to harden under water, it tends to expand, and this expansion is resisted by the metal reinforcement. If, on the other hand, the hardening takes place in air, the concrete tends to contract; and this contraction being again resisted by the metal, a series of fine hair cracks are produced, which, invisible at low loads, are readily detected on the tension side of a heavily-loaded ferro-concrete beam.

In view of the uncertainties introduced by the different factors above mentioned, it is really questionable whether, after all, the theoretically objectionable formula of M. Hennebique is not as good as any other. The latter all involve a preliminary calculation of the position of the neutral axis, which varies with the percentage of metal used, and with the type of stress-strain curve assumed for the concrete; and also with the maximum stress at any particular section. Thus, in a centrally-loaded beam its position at the ends is entirely different from what it is at the center. M. Hennebique, on the other hand, makes no attempt to locate this neutral axis, and simply assumes that one-half of his beam resists compression, and that the stress is uniformly distributed over this half. The moment of this compression about the center of the section he equates to half the moment due to the load, and the other half of the moment due to the load he equates to the moment about the center of the section of the tensile stress on the metal reinforcement. The working strength of concrete in compression he takes as 350 pounds per square inch, and neglects entirely its strength in tension. The working tensile stress on the steel reinforcement he takes as 14,000 pounds per square inch. The method is, of course, totally illogical, yet many thousand cubic yards of ferro-concrete have been successfully designed on these lines; and a comparison of the strength of ferro-concrete beams as calculated by this formula, and by those of a more rational type, shows very little difference between the two for a considerable range in the ratio of metal to concrete. On the other hand, it must not be forgotten that formulæ which are non-rational in form, are always risky when applied to extreme conditions.

Concrete being as weak in shear as in tension, provision is also required to take the shearing stresses. Some American designers have to this end patented special forms of reinforcement bar, in which each main tension bar has projecting upward from it ties inclined at an angle of 45 deg. These extend to the top of the bar and take the tensile stresses arising from the shear. The corresponding compressive stress at right angles to this is carried by the concrete. The system is doubtless efficient, and on large spans, where weight must be reduced to a minimum, it may have some advantage; but in work of ordinary proportions it seems to be little superior to the Hennebique system, in which the necessary strengthening is provided by stirrups of flat iron bent into a U shape. The main reinforcing bars rest in these stirrups at the lower ends. The spacing of the stirrups depends upon the "web stresses" to be taken, which can easily be calculated by assuming the reinforced beam to be a latticed girder, the lower chord of which is represented by the metal reinforcement, the upper one by the center of the compression half of the beam, while the stirrups represent vertical ties, which may be taken as connected together at top and bottom by inclined imaginary struts. The advantage of this simple method of reinforcing for shear lies in the possibility of using common rolled sections for the whole of the reinforcement.

M. Hennebique constructs most of his ferro-concrete work on the monolithic system, girders, piers, columns and floors being solidly connected together. It is, therefore, necessary to provide for the reversed bending moments over the points of support, which is done by bending up half of the total reinforcement bars, so that the ends of the span are close to the upper surface of the beam, and thus in a position to take the

* Engineering.

heavy tensile stresses which ensue at these points when the monolithic system of construction is followed. The exact calculation of the reactions and bending moments here is impracticable, if not actually impossible; and those engineers who attach much importance to having all structures statically determinate will doubtless object to the plan, but experience shows that the advantages gained are very considerable. The structure then resists as a unit, and in particular its rigidity is marvelous.

Some comparative tests on this point, made by the Orleans Railway Company, showed that with a ferro-concrete floor subjected to blows four times as heavy as were applied to an equivalent floor constructed of brick arches on steel joists, the deflection was only one-seventh as great.

The extreme rigidity attainable with the monolithic system of construction was also very evident in the case of the large Hennebique bridge at Purfleet. Since a structure fails by strain rather than by stress, the small deformations noted with ferro-concrete are evidence that as an average the material is relatively little tried by the loads carried. It must, however, be admitted that this low average strain is quite compatible with extremely severe strains at particular points; but it is, of course, the business of the designer, by suitably disposing his material, to avoid these possible local abnormalities.

Occasionally doubts have been expressed as to whether the metallic reinforcement may not suffer from corrosion as time goes on. This would be extremely dangerous if it occurred, since the metal being out of sight, its loss of strength might remain undetected until, some day, the structure might fail under its ordinary working load. Fortunately, much evidence is available to the effect that steel or iron thoroughly imbedded in concrete is permanently protected from rust. Americans, indeed, are so positive on this point that they have recently constructed a number of reservoir dams in ferro-concrete. In some cases these have been arched, but in others they have been straight. The cross-section in the latter case is generally a hollow triangle, the sides of which are connected together by diaphragm walls from point to point. The dam is also anchored to its site, though generally the weight provided is sufficient to make the structure safe against over-turning, quite apart from the help received from the anchor-bars.

Progress in the use of reinforced concrete has been somewhat slow in this country. Our railway engineers, in view of their enormous responsibilities, have not unnaturally hesitated to adopt a material in which it was impossible to calculate the strength with accuracy, and of which experience as to its reliability was very recent. In our cities, moreover, its use has, quite apart from this, been restricted by the inelastic nature of our building regulations, which have been drawn up on the assumption that finality had been reached in the matter of building construction. Hence permission to erect warehouses and factories in ferro-concrete has always been difficult—and often impossible—to obtain, though experience has shown that the new material is most excellent as a fire-resister. At the great Baltimore fire it was found that the concrete exposed to the flames was seldom damaged to a greater depth than one-half inch, though projecting corners suffered somewhat more, being rounded off by the flames to a radius of about 2 inches, pointing to the advisability of constructing the concrete with well-rounded corners in the first instance. The only reasonable grounds of objection to any proposed system of building construction are its dangers from a structural, sanitary, or fire-risk point of view.

THE MODERN GAS ENGINE.

THE crowded attendance at Mr. Dugald Clerk's recent course of Cantor lectures at the Society of Arts is ample evidence, if such be needed, of the very keen interest now being taken in internal combustion engines. The combined attraction of the subject and of the great name which Mr. Dugald Clerk has made for himself would, no doubt, have filled a larger hall. In five and twenty years the thermo-dynamic efficiency of steam engine and boiler has risen to about 10 per cent. In the same time the efficiency of the gas engine has leaped from 16 to 35 per cent. This shows vividly the recent advance made in gas-engine design and economy; it shows, too, that no longer is the steam engine in sole command of the field. With the several steps in the progress of steam-engine development we are not at present concerned, but we will refer to the more distinct phases which have marked the evolution of the modern gas engine. Up to the present time it has been customary for the ignition to take place in a volume which remained practically constant; hence the name, the "constant-volume cycle." Mr. Dugald Clerk was able to show by curve and by formula that a "constant-pressure cycle"—one in which the pressure due to explosion was leveled by expansion—would, for the same maximum temperature, yield a higher efficiency. Diesel's work on oil engines bears this out in practice.

Although it is customary briefly to speak of either constant-volume cycles or constant-pressure cycles, the actual processes followed out in gas engines deviate in a measure from these strict standards; thus, in the ordinary type of gas engine the piston does move slightly during explosion, and a Diesel engine indicator card shows that the pressure is by no means constant throughout combustion. Actual cycles lie between the ideal limiting conditions, and are known by the names of those they most nearly approach. The choice of cycle cannot, however, be said to have been the decisive factor throughout the whole of the life history of the modern engine, since it is only of late years that the constant-pressure cycle has received detailed attention. The increase in thermodynamic efficiency has been obtained by improvements in design, and greater economy in use has followed from improvements in fuel. The gas engine began by using ordinary coal gas as supplied for lighting purposes, although the cost of using so highly specialized a product was necessarily great. The introduction of producer gas came next and then followed the suction producer, which, instead of storing gas, produced it only as it was needed. Within the last few years has come the utilization of blast-furnace gas. In these later developments progress has been less marked in this country than on the Continent—not because of any greater industry on the part of the continental engineers, but on account, perhaps, of severer economic pressure. The latest development is the distribution of producer gas from large generating stations much after the manner of electric power distribution. An example of this will very shortly be working in the English Midlands.

This is the profile of the path along which the evolution of the modern large gas engine has proceeded. Interwoven with it there has been a curious scientific controversy as to the cause of the suppression of temperature on explosion and the effect, if any, of variable specific heats, if such exist. The controversy has not retarded progress—rather, by interesting thoughtful men, it has led to its advancement. With the various contentions put forward we have not space to deal.

In England at the present time many thousand horse-power are being produced from blast furnace gas, and the amount is certain to increase. One of the greater difficulties encountered lies in the dust carried over by the gas and the consequent wearing of the cylinder and valves. The provision of adequate scrubbing plant is the remedy, and gas of sufficient purity can now be produced. There are at least two types of gas engine capable of using this gas which are coming prominently into notice—the Koerting engine, made by Messrs. Mather & Plat, and the Oechelhauser engine, made by Messrs. Beardmore. The former has the advantage of a two-stroke revolution, and the latter possesses the merit of having no inlet or outlet valves to get out of order. Both types can now be seen working in this country.

With curious foresight Mr. Dugald Clerk was able, in 1882, to prophesy the introduction of combined suction producer and gas engine for ship propulsion, and at the present time practically the first boat of the kind is being built. Since the combined efficiency of suction producer and gas engine is about 30 per cent, it is clear that the quantity of coal consumed on a gas ship would be less than half the quantity which would be required by a steamship.

It seems probable that progress in the future lies in the development, in spite of obvious difficulties, of the more efficient constant pressure cycle. At the same time an addition to the efficiency could doubtless be produced by further improvements in design; better governing, greater regularity of turning moment, lower temperatures, and greater mobility are all of them desirable, and they will doubtless be in some measure attained. When evolution has been carried so far, there is no reason why gas engines should not be produced which, while capable of using the poorest kinds of coal, would convert into useful work at the shaft not less than 40 per cent of the stored-up energy of the fuel, or possibly even more. It is not without a measure of justification that the internal-combustion engine is spoken of as "the motor of the future."—London Times.

THE VELOCITY OF PROPAGATION OF X-RAYS.

M. R. BLONDLOT has recently made an experimental determination of the velocity of propagation of X-rays, as a result of which he finds that they travel with the same velocity as light. The full account of the work is published in the Comptes Rendus for October 27 and November 3 and 10 (vol. cxxxv. pp. 666, 721 and 763), and a translation of the first two papers is given in the Electrician for November 21. As the subject is one of great importance, the following brief abstract of the methods used and the results obtained may be of interest to the readers of Nature.

The method is based on a principle similar to that of Römer's method of determining the velocity of light. The arrangement of the apparatus is shown diagrammatically in the cut. B and B' represent the terminals of the secondary of an induction coil which are connected to the poles A, A' of a Hertz radiator and to the electrodes E, E' of an X-ray tube. Beneath the Hertz radiator is placed a resonator consisting of a copper wire folded into the shape of a triangle, $DD'C$. The spark gap, C, of this resonator is so placed that it receives the X-rays from the focus tube, but it is protected from all other radiation by screen of black paper and an aluminium plate. The oscillator AA' consists of two brass cylinders arranged horizontally in a bottle of vaseline oil. By suitably altering the length of the spark gap, the oscillator and the focus tube can be made to work simultaneously. The action is then as follows: At each current of break, the potential between E and E' rises sufficiently for the X-ray tube to respond. As the potential continues to rise, a spark passes in the oscillator, and this, withdrawing energy from the focus tube, extinguishes it. By careful adjustment, the spark potential of the exciter can be made only slightly greater than the potential necessary to work the tube, in which case the tube will be extinguished very soon after the beginning of the oscillatory discharge, at the end of a time less than a quarter of the period of the radiator. The electric force at the resonator gap only reaches its maximum after a time equal to half the period of the oscillator; hence if the X-ray tube is close to the gap, the X-rays having been extinguished prior to this, there can be no action of the tube on the secondary spark. This conclusion is verified by interposing a sheet of lead between tube and gap, when it is found that the spark is not affected.

Now let the focus tube be kept in the same position and the wires AE and $A'E'$ be lengthened each by the same amount. This has the effect of delaying the extinction of the tube by the time required for the Hertzian waves to traverse this extra length of wire, and consequently the disappearance of the X-rays at the spark gap C is delayed by the same amount. The X-rays can, therefore, act upon the spark, and that they do so is shown by the fact that the interposition of a lead sheet now makes the spark less bright. If, on the other hand, the wires AE and $A'E'$ are kept of constant length and the tube moved farther away from the gap, then the X-rays will experience a retardation equal to the time they take to travel from the tube to the gap.

The effect of moving the tube farther off should, therefore, be the same as that of lengthening the wires, and this is again confirmed by experiment; the spark grows brighter as the tube is moved away, but if a lead sheet be interposed, the brightness is unaffected by moving the tube. For a certain distance between tube and gap, the X-rays will have at the gap their full intensity during the whole of the time the potential at the gap has an appreciable value; at this point their effect is a maximum, for increasing the distance diminishes their intensity without increasing the time during which they and the electric force act together at the gap. This position of maximum can be found by experiment.

Let V and V' be the rates of propagation in centimeters per second of the Hertzian waves and the X-rays respectively, and after determining the position of the tube giving the maximum spark when the connecting wires AE and $A'E'$ are of given length, let these wires be lengthened by α cm. The cessation of X-rays at the gap is thus retarded by α/V seconds. In order to re-establish the coincidence of the times and to find the new maximum, the tube must be moved nearer the gap by length β cm., such that $\beta/V' = \alpha/V$. The experiment gives β/α, and therefore V'/V. The following table gives the results of a series of experiments, the first column gives the values of α, the second and third columns the values of β as determined by M. Blondlot himself and his assistant, M. Virtz, respectively, and the fourth column the mean of these two values. Each of the numbers in columns 2 and 3 is the mean of five determinations.

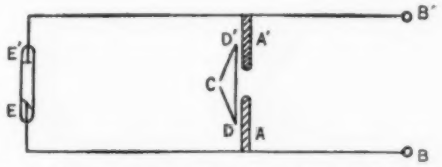


DIAGRAM OF M. BLONDLOT'S APPARATUS.

α	β		
	Blondlot.	Virtz.	Mean.
− 7	− 5.9	− 6.5	− 6.2
9	10.5	8.9	9.7
12.5	12	12.6	12.3
15	15.1	14.5	14.8
25	25.3	24.5	24.9
30	31	30	30.5
40	39.3	39.6	39.4
25	24.6	23.2	23.9

The mean result of all the experiments in this and other series gives the value 0.97 for the ratio V'/V.

A variation of the method was also tried in which the ends of the resonator were separated by 0.3 cm., and two wires soldered to them and connected to a micrometer spark gap. These wires were bent back on themselves so as to bring the new gap into the same position as the old one. The Hertz waves have to traverse these wires before producing the spark, and if each wire is lengthened by a cm., the spark is retarded by a/V seconds. To obtain the new maximum, the tube must be moved away from the gap by a distance b cm. such that $b/V' = a/V$. A number of very concordant experiments by this method gave a mean value 0.93 for the ratio V'/V.

The final result of all the experiments, therefore, leads to the conclusion that *the velocity of propagation of X-rays is equal to that of Hertzian waves or of light through the air.* M. Blondlot concludes his papers by pointing out that this conclusion is in harmony either with the hypothesis that X-rays are radiations of very short wave-length or with that of E. Wiechert and Sir George Stokes, that they are electromagnetic impulses produced by the impact between the molecules or electrons in the kathode stream and the antikathode. The fact brought out by these experiments that the X-rays

cease simultaneously with the current traversing the Crookes tube, also supports the latter hypothesis.—Maurice Solomon, in Nature.

LEAD PENCILS WE USE EVERY DAY.

Paper Lead Pencils.—A short time ago comparatively not a little stir was raised in the pencil-using world by the sudden advent upon the market of an innovation in the shape of a paper pencil, to all outward appearances indeed like every other pencil, yet differing from them in that no knife or other mechanical tool was required to repoint it. Instead of the usual wood covering, these paper pencils are inclosed in a shell of paper wound in a peculiarly spiral form, colored and polished on the outside with the intention of appearing like polished wood. The chief advantage of this pencil consists in the fact that to lay bare the lead no knife is needed; the finger nail or any handy pointed object is all that is required to dislodge a small paper bridge, whereupon a section of the covering is run off spirally, and about one-eighth of an inch of the lead is uncovered. They can be sold at a low figure, and the pointing with the hand is avoided, as well as the attendant danger of breaking the point.

Lead Pencils with Paper Covering According to Mahla.—The customary wooden covering for our lead pencils may now be replaced by a covering of paper, and the process is as follows: The graphite or colored stick of other material is wound either with the hand or a suitable machine with paper, and glue, paste, gum, or any other sticky substance used as a binder for the several layers.

Pencils made in this way are covered with red, black, or any other attractive colored paper, upon which the name of the firm has been previously printed. While still damp, these rolled pencils are placed in iron forms, and by means of a strong pressure they are molded either round, octagonal, hexagonal, or in any desired form. When taken from the forms, they are laid in double grooves to keep them straight, and dried at a moderate temperature. Having been thoroughly dried, they are varnished or not, just as are the ordinary wooden pencils, and cut off square at the ends for a finish.

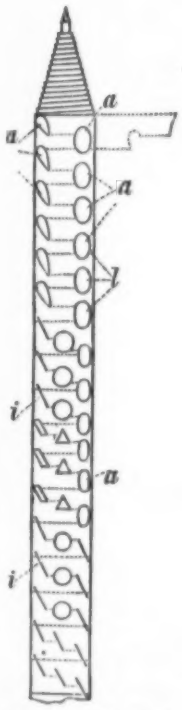


Fig. 1.—Lead Pencil with Paper Envelope by Bremer.

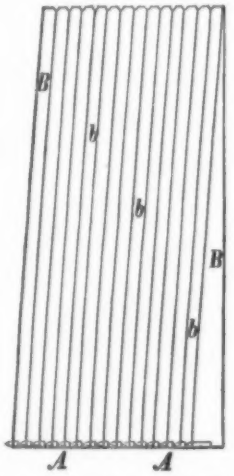


Fig. 3.—Graphite or Chalk Bits Arranged and Ready to be Rolled up in the Envelope.

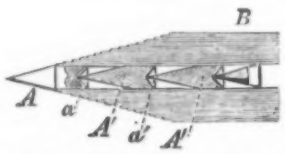


Fig. 4.—Bits of Graphite or Chalk with Hollowed Rear Ends.

Lead Pencils with Paper Covering According to Bremer.—These writing or drawing pencils, formed by covering the lead interior with layers of drawing or parchmented paper laid on spirally, differ from all other pencils of the kind, in that they have several rows of holes or incisions placed opposite to one another, whereby is afforded immediate access to the detachable strip, as well as a certain leading of the cut to the next line of incision. Up to this time such pencils were made with only one row of holes.

Under the old arrangement, when the point was used down, it became necessary, in order to release the next strip, to cut through the paper around the hole, either with a knife or with the thumb nail, as far as the next line of incision; moreover, as often occurred in tearing it off, the cut frequently ran up instead of down, and thus became disengaged from the detachable strip.

Now, if to avoid this inconvenience a strong downward pull were exerted when the strip was first disengaged, it also often happened that the cut slid into the lower strip, and this together with parts of the other came off together. The improvement which we show in Fig. 1 overcomes this undesirable defect. Several rows of opposing holes are shown at *a*, which lead the incision through every strip, *i*, with a certainty from hole to hole downward to the next cut, *l*, whereby there is provided in the following strip a suitable place for the insertion of the thumb nail when further pointing becomes necessary. These holes, *a*, may assume any desired shape or be of any number on the strip, *i*. Fig. 1 shows several examples of such holes in various forms and arrangement.

Instead of holes, simple incisions may be provided, which are oblique to the running strip, and which penetrate to or overrun them. Again, a combination of holes and incisions may be arranged. In every case we have the advantage of being able to insert the thumb nail, without further ado, under the corner of the incision line; and in drawing away the strip thus caught by the thumb and finger, be sure of leading the cut into the next lower-lying hole or incision, and from this into the following lower one or in its incision line without the aid of the knife. Again, the tearing away of the strip already partly disengaged, or a breaking through into the strip above and carrying all or a part of that with it, is avoided.

Lead Pencils with Paper Covering after Rockestraw.—This pencil consists of a combination of a number of pointed pieces of graphite or chalk, lying in contact with one another and arranged one behind the other, with an enveloping sheet of pliable material, which, in order to remove a portion of it easily, is provided with weakening lines running spirally around the handle. The method of constructing this pencil consists therein that the thick end of the pointed bits of graphite or chalk is held, by means of some adhesive material, between two weakening lines or scorings, so that when a part of the envelope is rolled off or removed, the piece of writing material, of which the point has been used away, will be removed with it and a new point appear. These bits of graphite or whatnot may be cut off square at the thick end, or hollowed out so as to receive the point of the next following piece, or may be united by a narrow webbing between the pointed and unpointed ends. In this case, when the envelope is removed, there remains only to break away the narrow webbing, and a new point is at once available. In Fig. 2 we present a longitudinal cross section of a pencil showing the arrangement of independent bits of pointed graphite or chalk. Fig. 3 shows the practical method of construction above described, indicating at the same time, that the thick ends are hollowed out conically for the reception of the point of the following piece.

By another method the pencil may be constructed so that the single strip of lead may have its diameter diminished at regular intervals along its course.

In Fig. 4, *A A' A'* represent the bits of graphite or chalk, having one end pointed and arranged one behind the other, all looking in the same direction. *B* is the envelope, which in Fig. 3 is shown as spread out, and in Fig. 5 as rolled up and finished.

The envelope is scored in parallel lines, and rolled about the pointed bits in the same manner as it has hitherto been done about the solid strip of lead. Before the envelope, *B*, is rolled about the bits, *A*, the latter are so arranged that the larger end of each bit falls upon a section of the envelope situated between each pair of scores, being retained there temporarily by some strong adhesive. As will be seen from the scheme in Fig. 3, the point of each separate bit now extends over into the preceding section.

From this it will be easily perceived that when one section of the paper envelope is removed, it carries the blunt end with it, and discovers a new point, the blunt end being fastened to the paper, as already said, by glue or paste. As for the construction, it is, in all cases, practically identical, slight variations only taking place in the formation of the bits. Some are cut off square and solid at the base, others are hollowed out conically for the reception of the succeeding point. Where the latter method is pursued, the buyer gets more pencil for his money, while the thick or holding end of the bit is not in the least impaired; but this construction rather permits of its being longer, and as a consequence making perhaps a stiffer pencil, an advantage in hard pencils, where more pressure is likely to be exerted; moreover, a longer and finer point may be given to the bit, by reason of the longer recess in the thicker end—all advantages these, which are not instantly appreciated. It may be further stated that if the points and the cylindrical part of the bits remain normal, by virtue of the recess, more points or bits may be inclosed in the same length of pencil, making in reality a longer wearing pencil. Again, the recesses may be of any desired form. As hinted at above, the solid strip of lead may be turned down at regular intervals to nearly the breaking point, and thus furnish a series of unbroken points, that present a series similar to the detached bits. When rolled into the scored envelope, the thick cylindrical parts must be placed with the bits between each pair of scores, so that when the section is rolled off, there remains but to break off the unused end, when the new point is ready for use. This method of manufacture does not appear to be so advantageous for the user, inasmuch as the point cannot be so fine and smooth as when previously pointed in the press.

Fig. 6.—Holder for Pens and Pencil Leads.

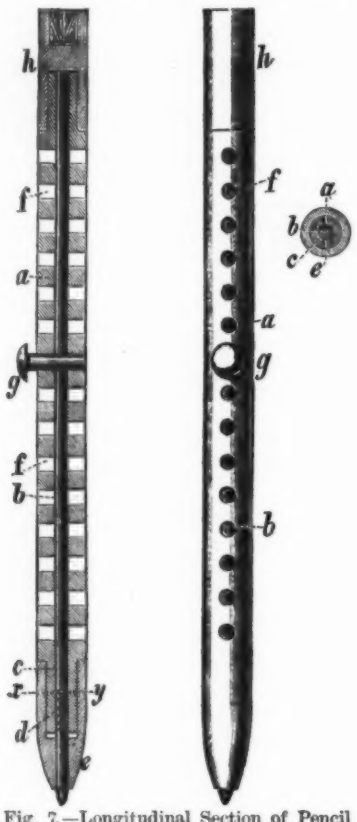


Fig. 7.—Longitudinal Section of Pencil with Loose but Adjustable Lead Shaft.
Fig. 8.—Side View of Same.

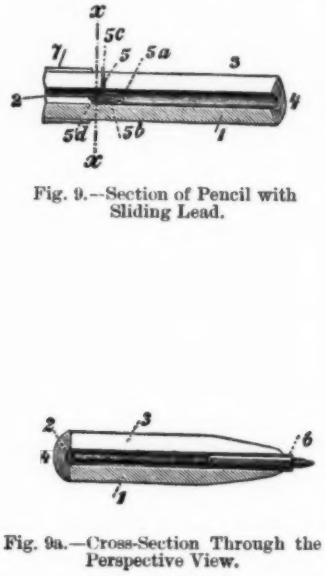


Fig. 9.—Section of Pencil with Sliding Lead.

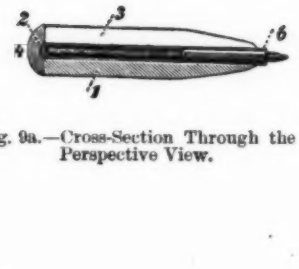


Fig. 9a.—Cross-Section Through the Perspective View.

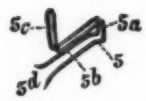


Fig. 10.—Enlarged Perspective of Slide for Pencil Shown in Fig. 9.

Fig. 2.—Longitudinal Cross Section Through the Pencil, Showing Independent Bits of Pointed Lead.

Fig. 5.—Longitudinal Cross Section of Pencil. Diameter of the Lead Shaft Decreased at Intervals.

Black and Colored Pencils with Longitudinally Detachable Wood Holder.—We are concerned here with black-lead or colored chalk pencils, in which the writing substance is enveloped by a material which, when it becomes necessary to repoint the pencil, may be easily peeled off with the finger, and thus avoid breaking away the lead, an annoying incident which often occurs when the sharpening is done with a knife. The lead is enveloped by a curl-like shaving of wood, turned off by a lathe, which is wound about its own axis, at a certain angle, so that it seems to be formed of helical cones one stuck within the other. Such a shaving

ought to be turned in one continuous piece from a rod, in such a manner that a solid core of the length of the rod can be taken from its center, in order that when the curl is again wound up, the spiral windings will produce a durable rod, having in its axis a hollow or tube adapted for the reception of the colored material. After winding the laps are held in position by applying some suitable adhesive to the outside, of which sufficient will penetrate between the interstices to hold it intact. Whenever the point of such a pencil needs renewing, it is simply necessary to peel off a number of the windings corresponding to the length of the point desired, which may be easily done with the finger. The ball-like end serves as a guide to the knife when applying it with a view to a finer point, and allows it to be cut symmetrically. For the envelope the material may be of any kind that allows of peeling off a certain prescribed curl-like shaving with the fingers.

Lead Pencils with Straw Envelopes.—The process of constructing an envelope of this kind is as follows: Into a small straw of suitable length push the strip of lead. Of course, the straw must never have been broken. Insert now lead and straw into another slightly larger straw. Repeat the operation as often as required to reach the desired thickness. When straws cannot be found of desirable diameter, they may be slit down one side and soaked in water for a few moments. Place in them a wire of the diameter next to be covered, and allow the straw to dry upon it; this too is to be repeated with other straws and larger wires. Of course, the last covering demands the largest straws obtainable. The lead and each successive straw is smeared with gum or paste just before it is slid into its respective covering, this to keep them together as a whole. The whole is now rolled in paper, pressed into shape, stamped, varnished, and otherwise finished. If preferred, the straw may be given the color of cedar.

A Holder for Pen-points and Pencil Leads.—This is an invention of Mr. C. R. Viehofer, of Berlin. It consists of a contrivance adapted for holding pens, and the lead for writing or drawing pencils, at once permitting them a pliability suitable to the work to be performed or causing them to remain absolutely rigid. We show this holder in Fig. 6 in longitudinal cross section, giving also cuts through the lines, *A B* and *C D*. For the reception of the pen, the ordinary pencil or the draftsman's pencil, we have a slotted shell, *a*, and a sleeve, *b*, pressed over it. The shoulder of the pen is inserted between the shell, *a*, and the sleeve, *b*, whereas the pencils are held in the shell, *a*, itself. The sleeve, *b*, is shaped in its upper part like a double cone, while its lower end takes the form of a cylinder. The under part of the shell, *a*, rests upon a plate spring, *c*, which passes through slits in the bottom and in the corners of a box, *d*, held in a recess bored in the end of the holder, and is adapted to be moved in these slits by means of a pin, *e*, which passes through and out of the holder by way of *f*. If the plate spring be pushed so far in the holder that the bottom of the sleeve, *b*, lies upon the box, *d*, then the elasticity of the plate spring equals *o*, and the writing pressure will be rigid or stiff. If, on the contrary, the plate spring be withdrawn from the holder, then the elasticity will be effectual, and the writing or drawing pressure will be springy. Since the plate spring is constantly between its guides, no chance lateral motion can take place.

The clamping pressure which the walls of the slot, *f*, exert upon the pin, *e*, is almost sufficient to retain the plate spring in any position it may assume. If this pressure be not sufficient, then pliable and spring tongues may be inserted in the box, *d*, adapted to exert special pressure upon the plate spring.

A Pencil with Loose but Adjustable Lead.—Dúnuem and Cooper are the inventors of a pencil or holder in which the shaft of lead or colored chalk is loose in the envelope, said holder being adapted, either through the addition of a conical shell at the bottom or by screws in the sides, to hold the lead in any desired position, in other words, to allow as much of the lead as needed to protrude from the holder. Again, in order to prevent the lead from forcibly re-entering the holder while in use, the latter is pierced at regular intervals with holes into which a pin fits snugly. This pin being inserted above the top of the lead shaft, acts as a block and stops further ingress.

In Fig. 7 we show a longitudinal cross section of such a holder, with the pin in position. In Fig. 8 we have the finished pencil, as seen from the side. Fig. 7 is intended to be hollow above the pin, else the pin could not pass through. The small figure beside Fig. 8 is a section through the holder perpendicular to its long axis on the line, *x y*, explaining the construction of the point end. According to this invention, a tube or any other suitable envelope, *a*, is made of wood or metal in the customary form, and adapted to receive a loosely-fitting staff of lead or chalk, *b*. The lower end, *c*, of the envelope, *a*, is of conical shape, rabbeted, having a bore of equal diameter to that running through the tube, *a*. The part, *c*, the extreme end of the tube, *a*, is split for a part of its length, as shown at *d*, Fig. 7. Upon the shoulder end, *c*, a pointed cap, *e*, is fitted, so that it forms a continuation of tube, *a*, furnishing a sharpened point. When the sleeve part of this cap is drawn upon the conical extremity, *c*, of the tube, *a*, it presses the slot, *d*, together, and pinching the lead, *b*, prevents it from falling out when the pencil is held downward. To place a lead shaft in the holder, remove the conical cap, *e*. The tube as shown is provided with a series of holes in the side. They may pass entirely through both sides, or may terminate in the interior hollow. A pin or pivot may be placed in these holes, *f*. When a pencil is to be used, remove the cap, *e*, draw out enough of the lead, *b*, for comfortable manipulation, and replace the cap, *e*, upon the part, *c*, so that at least the point of the graphite remains out. Now, by inserting the peg, *g*, close behind the upper end of the lead shaft, its position will be maintained.

After use, and when the pencil is about to be deposited in the pocket, withdraw the pin, *g*, and place it one or two holes further back, so that the lead may drop back into the holder and be protected. A point protector of the usual shape may be slipped over the upper end of the holder if desired. A pencil of this character possesses all the advantages of an ordinary wooden pencil without the necessity of using a knife to sharpen it, avoiding at the same time soiling the fingers.

Pencils with Adjustable Leads.—The invention now under consideration relates to that sort of lead pencil in which the lead is moved from without by means of a slide, and we shall show a method of construction which provides all the principal advantages possessed by mechanical pencils, the construction being at the same time so simple that this new pencil will not be any dearer than the well-known everyday wooden pencil. By consulting Fig. 9, and following the numerals

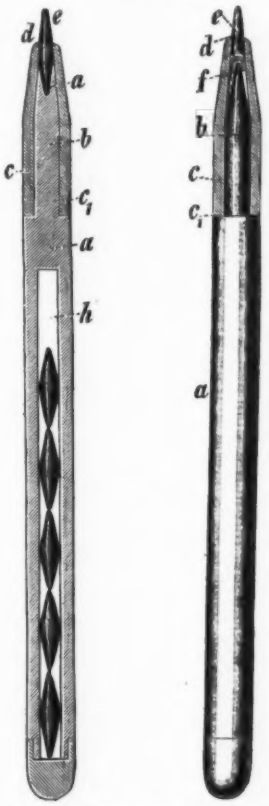


Fig. 11.—Cross Section of Pencil Having a Point Which Falls Into a Corresponding Recess in the Plug.

Fig. 12.—Pencil Showing Recess in Lead Point in Which the Corresponding Point of Plug Enters.

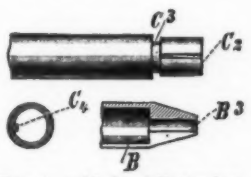


Fig. 19.—Mode of Fastening Conical Point.

Fig. 13.—Pencil with Threaded Graphite Shaft.

Fig. 14.—Point Freely Forced upon the End of Holder.

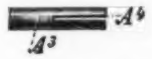


Fig. 15.—Slotted Sleeve for Holder.

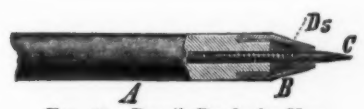
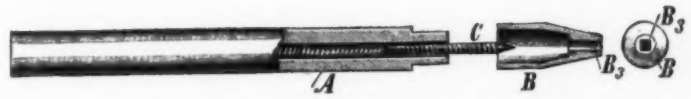


FIG. 16.—Pencil Ready for Use.

FIG. 17.



Figs. 16, 17, 18.—Different Forms of Construction.

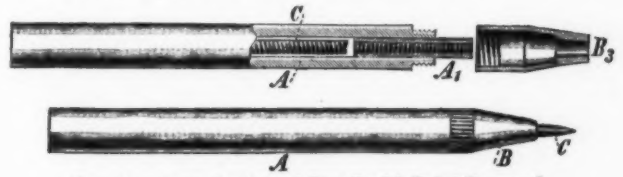


Fig. 20.—Cross Section of Pencil with Point Removed.
Fig. 21.—View of Pencil Ready for Service.

1 to 7 in the two views, we find that the form corresponds closely to the ordinary wooden envelope, except that it possesses a long slit on the side, extending from the central canal 2 to the outside. In the canal carrying the shaft of lead the pusher or slide, 3, is situated. This is made of a bit of wire, shown in Fig. 10, so bent that the grip, 5, the guide, 5*b*, as well as the pushing head, in contact with the lead, 5*a*, forms one piece. At the same time, the shanks, 5*b*, are spread out and pointed at their ends sufficiently to bind in the canal, and thus retain the pusher in position by sticking into the walls of the pencil holder and prevent any backward motion. In these pencils the lead is usually placed directly in the holder, but they can be made with a slotted conical sleeve in the point, as shown in the right-hand figure of Fig. 9, which is sprung in from the outside, which would prevent the lead from falling out when the wood shrinks away from it.

Pencil Holder with Short Interchangeable Leads.—Rudolph Spear, of Nürnberg, is responsible for this neat invention, and in it he seeks to overcome the usual annoyances arising from insufficient stability of the lead, by placing behind the lead in its position when in use a plug, which forms a part of the holder, and is provided at its lower end with a point adapted to enter a hollow in the unused end of the lead point. Of course, a recess may be made in the forward end of the plug, and it may then receive the suitably-shaped rear end of the reversible lead point. These conditions are shown respectively in Figs. 12 and 11. When constructed according to Fig. 11, a perfect centering of the lead ensues, and there remains no chance for shake. Considering then Figs. 11 and 12, we see that the holder consists in the main of two parts, the lower part about the thickness of the ordinary pencil shown as *a*, which is turned down at its upper end into a weaker plug, *b*, over which a conical cap, *c*, is slid and held in position, either by the friction of a tight, smooth fit or by any suitable mechanical contrivance. This cap is pierced at its upper end with an opening, *d*, which is of such shape and size that it holds rigid on all sides the bit of lead pressed into it from below. The insertion of a bit of lead takes place as follows: Turn the pencil down as if about to be put to use, remove the cap, *c*, drop into it one of the bits of lead, and replace it again upon the plug. The bits of lead are so measured that, when in position, with a little pressure its point will protrude through the opening in the cap, *c*, and be ready for immediate use. To provide greater stability in the connection between the point and the holder, the plug is provided with a recess adapted to envelop the pointed end of the reversible lead, or the plug itself may have a point adapted to fit into a recess cast in the back end of the bit of lead. Both constructions are shown in the accompanying figures.

Lead Pencils with Lead in Form of Screw.—The object of this construction is to obtain in the simplest manner the loosening and moving into a desired place the lead shaft within the holder. The shaft is therefore provided with a screw thread running about its entire exterior, while the canal within the holder is provided with a corresponding female thread.

We show this in Fig. 13 in a longitudinal cross section. The holder is preferably made of wood, and may have any of the forms common to the outsides of pencils, round, square, flat, ovoid, or hexagonal. The writing material, *e*, is of either graphite or chalk, and the pitch of its thread is so low that ordinary pressure upon the point, when in use, will not drive it back into the holder, though it turns so easily in its matrix that it requires no other tools than the fingers to draw it down. When the point becomes dull, it may be grasped firmly between the thumb and finger, and by carefully turning the holder drive more of the lead out. If by chance it break off too short to grasp, or by inadvertence the holder be revolved in the wrong direction, and the lead drawn in instead of being forced

out, a sharp knife will remove sufficient of the wood about the point to obtain a hold, when we proceed as before. According to another method of constructing the holder, we have at the forward end a head detachably fixed to the holder; that is, it may be either screwed on or be in the shape of a cone, and forced into a corresponding recess in the holder. In a case such as this, when the lead is broken off too short to grasp with the fingers, there will be no call for the knife as above; rather remove the head piece, take hold of the lead behind it, and screw out what is wanted. There is still another method of getting at the lead without the necessity of a special removable head. Let the end of the holder itself be made so that it may be turned about its long axis; provide it with a square or oval hole through which the square or oval lead shaft passes slidingly. Now, when this end is turned, the lead shaft will also be turned in the threads of the holder and forced either in or out. Among the views we show are a variety of these forms. Fig. 14 is a longitudinal view, showing point removed, which is also given in cross section. Fig. 15 shows the slotted insert for the point. Fig. 16 shows pencil ready for use, with the point cut away to disclose the threaded lead. Fig. 17 shows a method of construction in which the conical point is forced over the end of the pencil proper. Figs. 18 to 21 exemplify other methods of construction. Fig. 19 shows one manner of fastening the point to the holder. In looking at Fig. 17 again, we see that the holder, *A*, is provided with a thread either directly applied to the holder or contained in an inserted tube as shown in Fig. 20. This inserted piece can be made in any convenient and suitable way, and consists, for example, of a tube, A^2, slotted at A^1 (see Fig. 15) which affords an easy method of removing the lead from the holder if it be broken off short. In that case, the graphite strip is not round, no more is the bore, B^2, of the point, *B*, to which it corresponds in form, having, however, no threads. It is patent therefore that when the loosely-fitting point is turned, the lead is turned with it, revolving in the threads cut in the interior of the holder, and must accordingly move one way or the other.

In the construction according to Fig. 17, the holder is enveloped in a thin shell, D^2, upon which the point, D^1, is wedged. Now, the movement of the internal lead may be brought about either by turning the holder through the medium of the milled head, D^3, or by turning the point, D^1.

In the construction shown in Fig. 16, the holder, *A*, is shown slotted, so that the point is retained in position by elastic expansion. There is a bulge, D^5, in the point, and this grasps the graphite with a strong frictional hold. Fig. 18 shows the point with its hold upon the holder. In Fig. 19 we see a method of retaining the point in position. Inside of the point is situated a boss, C^3, which fits into the long slot, C^2, passing beyond it into the groove, C^5, where by a slight turn out of line with the slot it is locked.

[Concluded from SUPPLEMENT No. 1533, page 24570]

COPPER AS AN ALGICIDE AND DISINFECTANT IN WATER SUPPLIES.

By KARL F. KELLERMAN.

As many of the algæ occurring in water supplies are very minute, it is often necessary to resort to special methods to collect samples for identification. In some instances it is sufficient merely to allow a jar of the water in question to remain undisturbed for a few hours, when the algæ will have settled to the bottom, and it will be possible with the aid of a pipette or a small glass tube to remove a sample of this deposit to the glass slide for examination. If the organisms are motile, or if it is desired to estimate their number per cubic centimeter, the method described as the Sedgwick-Rafter method is the best for this purpose. The numerous requests for a means of determining quantitatively the algæ in water warrants the following extensive quotation:

THE SEDGWICK-RAFTER METHOD OF QUANTITATIVE DETERMINATION.[3]

The Sedgwick-Rafter method consists of the following processes: The filtration of a measured quantity of the sample through a layer of sand upon which the organisms are detained, the separation of the organisms from the sand by washing with a small measured quantity of filtered or distilled water and by decanting, the microscopical examination of a portion of the decanted fluid, the enumeration of the organisms found therein, and the calculation from this of the number of organisms in the sample of water examined. The essential parts of the apparatus are the filter, the decantation tubes, the cell, and the microscope with an ocular micrometer.

The Filter.—The sand may be supported upon a plug of rolled wire gauze at the bottom of an ordinary glass funnel 7 or 8 inches in diameter, but the cylindrical funnel . . . is preferable. The inside diameter of this funnel at the top is 2 inches, the distance from the top to the beginning of the slope is 9 inches, the length of the slope is about 3 inches, the length of the tube of small bore is 2½ inches, and its inside diameter is one-half inch. The capacity of the funnel is 500 cubic centimeters. The support for the sand consists of a perforated rubber stopper pressed tightly into the stem of the funnel and capped with a circle of fine silk bolting cloth. The circles of bolting cloth may be cut out with a wad cutter. Their diameter should be a little less than that of the small end of the rubber stopper. When moist, the cloth readily adheres to the stopper. The sand resting upon the platform thus prepared should have a depth of at least three-fourths of an inch. The quality of the sand is important. Ordinary sand is unsatisfactory unless very thoroughly washed. Pure ground quartz is preferable. Its whiteness is a decided advantage. The necessary degree of fineness of the sand depends somewhat upon the character of the water to be filtered. A sand which will pass through a sieve having 60 meshes to an inch, but which will be retained by a sieve having 120 meshes, will be found satisfactory for most samples. Such a sand is described as a 60-120 sand. When very minute organisms are present a finer sand must be used, say, a 60-140 sand. The sand used for many years by the author had the following composition:

Size of sand grains.	Percentage by weight.
40- 60	20
60- 80	20
80-100	38
100-120	18
120-140	4

The sample to be filtered may be measured in a graduated cylinder or flask, or the filter funnel itself may be graduated. The graduated filter funnel is especially useful for field work, as it saves the necessity of carrying an additional graduate. The quantity of water that should be filtered depends upon the number of organisms and the amount of amorphous matter present. An inspection of the sample will enable one to judge the proper amount. Ordinarily 1,000 cubic centimeters for a ground water and 500 cubic centimeters for a surface water will be found satisfactory. In some cases 250 cubic centimeters or even 100 cubic centimeters of a surface water will be found more convenient. When the water is poured into the funnel, care should be taken not to disturb the sand more than is necessary, otherwise organisms are liable to be forced through the filter. The best plan is to make the sand compact by pouring in enough distilled water to just about fill the neck of the funnel and to pour in the measured sample before the sand has become uncovered. The filtration ordinarily takes place in about half an hour, but occasionally a sample is so rich in organisms and amorphous matter that the filter becomes clogged. It then becomes necessary to agitate the sand with a glass rod or to apply a suction to hasten the filtration. If the filters are located near running water an aspirator may be attached to the faucet and connected with the filter by a rubber tube having a glass connection that fits the bore of the rubber stopper. The use of the aspirator enables the filtration to be made in a few minutes, and not only effects a saving in time, but reduces the error caused by the organisms settling on the sloping surface of the funnel.

Concentration.—As a result of the filtration the organisms and whatever other suspended matter the sample contained will have been collected on the sand. When all the water has passed through and before the sand has become dry the rubber stopper is removed and the sand with its accumulated organisms is washed down into a wide test tube by a measured quantity of filtered or distilled water delivered from a pipette or an automatic burette. The amount of water used for washing depends upon the number of organisms collected on the sand. If 500 cubic centimeters of the sample are filtered it is usually best to wash the sand with 5 cubic centimeters, thus concentrating the organisms one hundred times. The amount of water filtered divided by the amount of water used in washing the sand gives the "degree of concentration." The degree of concentration may vary from 10 to 500, according to the contents of the sample. Ordinarily it should be 50 or 100.

By shaking the test tube the organisms will become detached from the sand grains. If this is followed by a rapid decantation into a second test tube most of the organisms, being lighter than the sand, will pass over with the decanted fluid, while the sand is left upon the walls of the first tube. To insure accuracy the sand should be washed a second time and the two decanted portions mixed together. If, for example, it is desired to concentrate a sample from 500 to 10 cubic centimeters, the sand should be washed twice with 5 cubic centimeters and the two portions poured together. This will give a more accurate result than a single washing with 10 cubic centimeters.

It is necessary to allow for the volume of the sand and to use a definite amount of sand at each filtration. The 60-120 sand holds about 50 per cent of water, and ordinarily about 2 cubic centimeters of the sand are used; hence an allowance of 1 cubic centimeter must be made for the water held in the sand.

The Cell.—The cell into which a measured portion of the concentrated fluid is placed for examination is made by cementing a rectangular brass rim to an ordinary glass slip. The internal dimensions of the cell are: Length, 50 millimeters; width, 20 millimeters, and depth, 1 millimeter. It therefore has an area of 1,000 square millimeters, and a capacity of 1 cubic centimeter. A thick cover glass (No. 3) having dimensions equal to those of the outside of the brass rim (55 by 25 millimeters) forms a roof to the cell. The concentrated organisms in the decantation tube are distributed uniformly through the fluid by blowing into it through a pipette, and 1 cubic centimeter of the fluid is then transferred to the cell in such a manner as to distribute the organisms evenly over the entire area. This may be done by laying the cover glass diagonally over the cell so that an opening is left at either end, and flowing the water in at one end while the air escapes at the other.

The Microscope.—An expensive microscope is not needed for the numerical estimation of the common microscopic organisms found in water. A simple, compact stand with a one-half inch objective and a 1-inch ocular is sufficient. For studying the organisms in detail and for general laboratory use in the study of water a large stand, with substage condenser, iris diaphragm, mechanical stage, etc., should be provided. The list of objectives should include a 2-inch, a one-half inch, a one-fourth or one-sixth inch, and a one-twelfth inch homogeneous immersion, or their equivalents, and there should be several oculars magnifying from four to twelve times.

The ocular micrometer consists of a square ruled upon a thin glass disk, which is placed upon the diaphragm of the ocular. The square is of such a size that with a certain combination of objective and ocular and with a certain tube length of the microscope, the area covered by it on the stage is just one square millimeter. For convenience it should be subdivided. The size of the largest square is one square millimeter. The size of the smallest square is one standard unit. The standard unit is represented by the area of a square 20 microns on a side—i. e., by 400 square microns. With a one-half inch objective and a No. 3 ocular the square ruled for the ocular micrometer should be 7 millimeters on a side. Before using the micrometer the proper tube length must be ascertained by comparison with a stage micrometer.

Enumeration.—The cell, filled with the concentrated fluid, is placed upon the stage of the microscope and the organisms included within the area of the ruled square are counted. It is then moved so that another portion of the cell comes into the field of view and another square is counted. This is continued until a sufficient number of representative squares have been examined. It is obviously impracticable to count all of the 1,000 squares which compose the area of the cell. It is usually sufficient to count ten or twenty squares, but a larger number ought to be scrutinized. In counting the organisms it should be remembered that some are heavy and sink to the bottom, while others are light and rise to the top. The observer should make a practice of changing the focus of the microscope so that both the upper and lower portions of each square may be examined.

From the number of organisms found in the ten and twenty squares it is an easy matter to calculate the number originally present in 1 cubic centimeter of the sample. If t represents the number of organisms found in 20 squares, $\frac{t}{20}$ will represent the number found in one square, and $50\ t\ (= \frac{t}{20} \times 1{,}000)$ will represent the number in the entire cell, or in 1 cubic centimeter of the concentrated fluid. This divided by the degree of concentration will give the number of organisms in 1 cubic centimeter of the sample.

METHOD OF APPLYING COPPER SULPHATE.

Before introducing the copper sulphate it is necessary to determine accurately the volume of water to be treated. This is imperative in the case of municipal supplies and large reservoirs, as an error in the estimation might cause considerable inconvenience. Many cases will arise, however, in which a rough computation will be much more convenient and entirely practicable.

The method considered most practicable in introducing copper sulphate into a water supply has been outlined in a previous publication,[4] from which we quote:

"Place the required number of pounds of copper sulphate in a coarse bag—gunny sack or some equally loose mesh—and attaching this to the stern of a rowboat near the surface of the water, row slowly back and forth over the reservoir, on each trip keeping the boat within 10 to 20 feet of the previous path. In this manner about 100 pounds of copper sulphate can be distributed in one hour. By increasing the number of boats and, in the case of very deep reservoirs, hanging two or three bags to each boat, the treatment of even a large reservoir may be accomplished in from four to six hours. It is necessary, of course, to reduce as much as possible the time required for applying the copper, so that for immense supplies with a capacity of several billion gallons it would probably be desirable to use a launch, carrying long projecting spars to which could be attached bags each containing several hundred pounds of copper sulphate."

The substitution of wire netting for the gunny-sack bag allows a more rapid solution of the sulphate, and the time required for the introduction of the salt may thus be considerably reduced.

The temperature has such great influence on the effect of copper upon polluting forms that it is best to select as warm a day for treating as circumstances will permit.

STERILIZATION OF BACTERIA-POLLUTED WATER BY MEANS OF COPPER SULPHATE.

Treatment with copper sulphate is an effective and practicable means of sterilizing water polluted with certain pathogenic bacteria, and as an emergency method is applicable to both household and municipal conditions. It should prove particularly useful in very large water supplies accidentally or suddenly contaminated with typhoid bacilli and not provided with any adequate means of purification. Under such circumstances the case becomes not one of pure water versus water containing copper sulphate, but of sterile water containing an amount of copper not dangerous to health versus water and typhoid bacilli. The method former-

[3] "The Microscopy of Drinking Water," by G. C. Whipple, New York, 1899, p. 15.

[4] Bulletin No. 64, Bureau of Plant Industry, p. 25.

ly suggested[7] for treating a reservoir would undoubtedly be advisable in special cases of unusually great contamination when the water contained an abnormal amount of organic matter, but in general an epidemic could be controlled and quickly eradicated by a solution much weaker than the 1 to 100,000 listed as necessary for complete sterilization within twelve hours. One to 2,000,000 is sufficient in most cases, and even less than this quantity of copper is of decided benefit in certain kinds of water.

STERILIZATION OF WATER BY MEANS OF METALLIC COPPER.

The effect of metallic copper upon *Bacillus typhi* in water is of considerable importance. For small amounts of water it has been found convenient and desirable in many cases to guard against bacterial contamination by employing copper tanks, and where frequent boiling can not be resorted to, the use of copper may be regarded as the only possible safeguard. In some cases this may not be absolute, for our experiments upon water from various places and the experiments of other investigators show that the chemical constitution of the water under consideration is of the greatest importance. Water that contains a very large amount of matter in suspension is perhaps the most difficult to sterilize. Under these conditions twenty-four to forty-eight hours at room temperature would probably be necessary for complete sterilization through the agency of metallic copper tanks; on the other hand, metallic copper in water containing a large amount of organic acid, or free acid of any sort, would destroy all typhoid bacilli in two or three hours at the most. Complete sterilization is a standard to which even the best filters seldom attain, and under the most unfavorable conditions the reduction in the number of bacteria in water exposed to the action of metallic copper for twelve hours will be approximately as great as in a filtered water. The copper must be kept clean, not, as is popularly supposed, to protect the consumer from copper poisoning, but because it is possible for the metal to become so coated with foreign substances that there is no longer any contact of copper and water, and hence no antiseptic action.

An interesting corroborative fact is the antiseptic property of copper coins. Lately considerable work has been done on this problem by the department of health of the city of New York,* and, as was to be expected, it was found that copper and nickel coins smeared with cultures of pathogenic bacteria, such as *Bacillus diphtheriæ*, were completely sterile in a few hours, and that the same was true to a less degree of silver coins.

In a recent article, Dr. Henry Kraemer reviews the applicability of the germicidal power of copper to drinking water, and his results with the Philadelphia water show that standing four hours in the presence of copper foil completely destroyed both *Bacillus typhi* and *Bacillus coli*.

Doctor Kraemer's conclusions are quoted below:†

"In filtration processes it is generally understood that both typhoid and colon organisms are the first to be eliminated, and without waiting to make a systematic study of the organisms which persist as well as those which are killed in the copper treatment of water, I thought it well to test the method by using water containing these organisms alone. As results depend in some measure upon the method used, I will try to outline my method before giving my results.

"1. Water under three different conditions was employed: (*a*) Distilled water which was prepared from tap water by first treating it with potassium permanganate and then distilling it two or three times by means of apparatus constructed entirely of glass; (*b*) filtered tap water, prepared by means of a Berkefeld filter attached to a copper spigot; (*c*) tap water, collected after being allowed to run through a copper spigot for five minutes. All of these were sterilized in an autoclave at 110 deg. for thirty minutes.

"2. The cultures of typhoid and colon which were used were pure cultures developed in bouillon for eighteen hours to twenty-four hours.

"I may say that every single experiment which we have conducted . . . shows that copper foil is exceeding toxic to colon and typhoid bacilli, particularly the latter.

"It will be seen by consulting the tables that in the filtered water, to which no copper foil had been added, the typhoid organisms did not grow and multiply as was the case with the tap water and distilled water, although there was a larger number of organisms to begin with. This also applies in a measure to the colon bacilli, with which there is a very marked inhibiting action in those growing in the filtered water.

"At first I was inclined to attribute this diminution in the number of the organisms to minute traces of copper in the flasks, but subsequent experiments showed that this was not the case. I am, therefore, inclined to attribute these rather anomalous results to the presence of extremely small quantities of copper dissolved by the water in its necessarily slow passage through the copper spigot to which the filter was attached. This is a phase of the problem to which I am devoting my attention at present, as it certainly opens up an interesting side of this subject.

"Even granting the efficiency of the boiling of water for domestic purposes, I believe that the copper-treated water is more natural and more healthful, inasmuch as the various inorganic constituents, particularly the salts of calcium and magnesium, are in a more soluble and assimilable condition, being furthermore less concentrated, at the same time the natural gases of the water being retained.

"From the experiments thus far conducted the following conclusions may be drawn:

"1. The intestinal bacteria, like colon and typhoid, are completely destroyed by placing clean copper foil in the water containing them.

"2. The effects of colloidal copper and copper sulphate in the purification of drinking water are in a quantitative sense much like those of filtration, only the organisms are completely destroyed.

"3. Pending the introduction of the copper treatment of water on a large scale the householder may avail himself of a method for the purification of drinking water by the use of strips of copper foil about 3½ inches square to each quart of water, this being allowed to stand over night, or from six to eight hours, at the ordinary temperature, and then the water drawn off or the copper foil removed."

Doctor Pennington, of Philadelphia, has reported[10] results of the board of health laboratory, showing complete sterilization of infected tap water within fifteen minutes by means of copper foil.

Rideal and Baines[11] have carried on some experiments concerning the germicidal effect of copper. Evidently they added too much of the culture to be tested to the treated water. The high concentrations required according to their tables to produce complete sterility can be explained only by the presence of considerable amounts of albuminoid matter, and under these circumstances the condition is comparable to sterilizing sewage rather than sterilizing drinking water. Their experiments with metallic copper, though too few to be themselves at all conclusive, are entirely in accord with the results of the Laboratory of Plant Physiology as formerly published.

COPPER IN THE DISPOSAL OF SEWAGE.

In connection with the sterilization of water by means of copper the possibility of using this metal in the sanitary disposal of sewage should be mentioned. This is well described by Rideal,[12] from whom we quote:

"The soluble salts of copper have a distinctly poisonous action on bacteria. They coagulate albumen and combine with most of the organic acids present to form non-putrescible salts. They absorb sulphureted hydrogen, ammonia, and compound ammonias, and therefore combine with 'ptomaines.' In fact, copper salts rank next to mercury in power as antiseptics. . . .

"Kroncke[13] contended that, for sewage treatment, compounds having a great affinity for sulphur should yield the best results. He has experimented with cuprous chlorid as being a salt which fulfills this condition, is readily prepared, very easily removed from solutions, and becomes much less poisonous when oxidized. He used the following method for the purification of water: Cuprous chlorid amounting to one twenty-thousandth of the liquid to be treated, and ferrous sulphate (as far as possible free from ferric) to the extent of one fifty-thousandth, are mixed with the water. After six hours one one-hundred-thousandth part of lime is added, and agitated for one hour. After settling for one and a half hours, and filtration through sand, the water, which originally contained 40,000 to 50,000 organisms per cubic centimeter, was found to be completely sterilized, clear, almost colorless, and free from iron and copper. The sand filter can be used a long time without cleansing. Schumburg[14] reports that a water treated with cuprous chlorid solution and then with lime was free from germs after six hours."

COPPER SUPPLEMENTING THE USE OF FILTERS.

It appears from the examination of a considerable number of filters in this country that the officials in charge of municipal waterworks are not justified in assuming that filtration is the absolute guarantee against a disease-laden water that it is popularly supposed to be. The number of unavoidable accidents which are known to occur in properly managed filters, to say nothing of the willful and sometimes criminal methods resorted to in order to bring the supply of water up to the daily demand, are factors which are not generally considered by the public. The mere fact that filters are installed seems to warrant neglect of the source of the water, and as a mistake or an accident usually can not be detected by the public until the death rate increases markedly, filtration as administered in a considerable number of cases has resulted in a condition more dangerous than if no filter existed. The sooner that it becomes generally known that any sort of filtration is a most delicate process, depending upon skilled manipulation for maximum efficiency, the better it will be both for filtration and the consumer of water. That it is not an unheard of practice to force considerably larger quantities of water through a sand filter than it can possibly free from disease germs (even resorting to spading over the sand to hasten the flow) ought to be understood by all those using such water. The direct pumping of polluted river water into the filtered water for the purpose of making up the daily supply has been resorted to, and the occurrence of breaks in storage basins, conduits, etc., has more than once afforded opportunities for the dangerous contamination of the filtered water.

At the present time the only known method of immediately rendering a contaminated water supply safe and keeping it so until the source of pollution is removed seems to be the use of copper. This treatment is not designed to supplant efficient filtration, however, and should never be expected to take its place. The use of copper for removing a temporary contamination is necessarily a remedy and should be used as such. As much care is demanded of the sanitary engineer or biologist in determining the necessity for treatment and the proper quantity to be used as is demanded of a doctor in determining the dose for a sick person. A pure water should not be treated, just as a well person should not take medicine.

The existing methods of sewage disposal and water purification are particularly unfortunate. To deliberately contaminate a water and then try to purify it seems ridiculous, yet this is precisely what is now being done in a number of communities. The ultimate solution of the problem of water supply must depend upon proper sewage disposal as well as the proper care and policing of the watersheds and wells. Until this revolution of methods shall have taken place, the makeshifts—filtration, and treating with copper—are the only remedies applicable on a large scale.

[7] Bulletin No. 64, Bureau of Plant Industry, p. 33.

[8] Report of Dr. Wm. H. Park, March 1, 1904.

[9] Henry Kraemer, "The Efficiency of Copper Foil in Destroying Typhoid and Colon Bacilli in Water," American Medicine, February 18, 1905, Vol. IX, No. 7, p. 275.

[10] At a meeting of the Washington Academy of Sciences, January, 1905.

[11] S. Rideal and E. Baines, The Suggested Use of Copper Drinking Vessels as a Prophylactic against Waterborne Typhoid, Journal of the Sanitary Institute, XXV, 1904.

[12] Rideal, "Disinfection and the Preservation of Food," New York, 1903; pp. 156, 157.

[13] Jour. für Gasbeleucht, XXXVI, 513.

[14] Chem. Centr., 1900, II, 203.

A LITTLE-KNOWN PROPERTY OF THE GYROSCOPE.*

To my surprise I have found that the property of the gyroscope which I am about to describe, although perfectly elementary, appears to be little known to either physicists or astronomers. Neither is it mentioned in the text-books so far as I am aware. That it has a very important bearing on the mechanism of the solar system has been shown in some of my earlier papers, but the laws which govern the rotation and the simple facts themselves seem to be so little understood that I have thought it worth while to explain them more fully in this place.

If a gyroscope is mounted on gimbals so that it may shift its plane of rotation freely about an axis passing through the plane of the revolving disk, we shall find it is possessed of certain curious properties. To most persons the notable characteristic of a gyroscope is the resistance it offers to any force tending to change the plane of its rotation. This is true of it only, however, in case certain conditions are complied with. If these conditions are neglected, it will change its plane with the greatest facility.

If the wheel is properly balanced and mounted as above described, and we set it spinning, it will continue to rotate in one plane without change until it stops. Suppose that while it is spinning we set it upon a table, and cause the stand supporting it to revolve slowly about its vertical axis. Instantly the wheel will adjust itself so as to revolve in a plane parallel to the surface of the table.

Furthermore, the direction of rotation of the wheel upon its axis will be the same as the direction of rotation of the stand. If we turn the stand in the opposite direction the wheel will at once shift its plane, and turn over, so as again to rotate in the same direction as the stand.

Another way of showing the experiment is to hold the stand supporting the gyroscope at arm's length. The observer then slowly revolves upon his heels, first in one direction and then in the other. Each time the observer shifts his own direction of motion the gyroscope will shift its plane, and always in such a manner that its direction of rotation shall be parallel and in the same direction as its revolution in its orbit.

It is a well-known fact that according to the nebular hypothesis all the planets should have rotated in a direction opposite to that of their revolution in their orbits, just as Neptune does at the present time. This is because by Kepler's laws the inner edge of a revolving ring must necessarily move faster than the outer edge. The fact that Neptune is the only planet that even approximately fulfills this condition has always been a source of trouble to the adherents of the nebular hypothesis. No one has ever even attempted to explain the anomalous rotation of Uranus, in a plane practically perpendicular to the plane of its orbit.

The interesting property of rotating bodies illustrated above in the case of the gyroscope, and fully explained by its theory, now at once makes the matter perfectly clear. In the case of the planetary bodies, the force rotating the stand of the gyroscope is supplied by the annual tide raised upon the planets by the sun. In former times, when the planets were large diffuse bodies, this tidal force was of considerable importance. Neptune, however, is so remote from the sun that the tidal influence upon it has always been small. The plane of its rotation, therefore, has been but slightly shifted from that of its orbit—about 35 deg. Uranus being nearer the sun has had its plane shifted nearly half-way over, or through 82 deg. The plane of rotation of Saturn has been shifted through 153 deg., while that of Jupiter has suffered a nearly complete reversal, and the planet now revolves approximately in the plane of its orbit. The deviation amounts to but 3 deg., and its plane of rotation has therefore shifted through 177 deg.

The explanation of the retrograde rotation of Phœbe is now also clear. Phœbe, the first-born of Saturn's numerous retinue, came into being while the planet itself still retained its original plane of rotation, that is, while it was still revolving in a retrograde direction. Before Iapetus, Saturn's second satellite, reckoning from without inward, was created, the mighty tides acting upon the planet in its then diffuse condi-

* Nature.

tion had shifted its plane of rotation more than 90 deg. Two forces then acted on the plane of the orbit of the new satellite, one from the sun tending to bring the orbit into the plane of the orbit of Saturn, the other from Saturn tending to bring the orbit of the satellite into the plane of the equator of its primary. At first both forces tended to produce the same result, namely, to diminish the angle of inclination of the plane of the orbit of the satellite. They are now pulling in opposite directions, as is the case with our own moon, the inclination of the orbit of Iapetus, 19 deg., being less than that of the equatorial plane of its primary.

The inner satellites of Saturn are more powerfully affected by the equatorial expansion of the planet than by the action of the sun, the planes of their orbits, 27 deg., coinciding nearly with the plane of the planet's equator.

WILLIAM H. PICKERING.

Harvard Observatory, Cambridge, Mass., U. S. A.

AN ARTIST'S PROPHECY.

THE accompanying picture, reproduced from the London Illustrated News, is entitled by the editor of that journal, "The World of To-morrow: Some Dreams of Invention Run Riot."

Either the editor or the artist does not know that most of his conceptions have already been realized, and that some, so far from belonging to the world of to-morrow, are already of the world of the past. In the title to the first picture, seeing and feeling at a distance by means of an apparatus that bears the much-promising name "Telephote," the artist states that it is one of the dreams of science to supplement the telephone with an instrument which would permit us not only to see the persons we are speaking to, but to shake hands with them and actually experience their touch. We are quite unaware of any such desire. The editor adds facetiously that this would do so long as the parties conversing did not come to blows. To a practical inventor, it must seem rather a useless task to invent a device for shaking hands with a man at the other end of the wire. Politics, to be sure, is usually associated with hand-shaking, but we doubt very much whether the ordinary transactions of future business life will be quite dependent upon that form of greeting.

The newspaper of the future is another subject which the artist has chosen, the idea being to communicate news by huge gramophones, while the actual events are to be shown by the kinematograph simultaneously with their occurrence. The picture which we reproduce is supposed to be the image of a political orator who is at once visible and audible to unhappy audiences at many points. It may be mentioned for the benefit of the artist, that ever since the telephone was invented, it has become rather fashionable to give dinner parties at which the guests have the questionable pleasure of listening to a concert given hundreds of miles away. This part of the artist's fantasy is, therefore, not a thing of the future.

The central picture bears the title "Nightmare of the Street of the Future." That picture quite surpasses our comprehension. Trains wind in and out; a gentleman sits in front of his house, comfortably drinking his coffee; a lady, presumably his wife, is listening to the dulcet strains of a phonograph. The scene, so far from being a nightmare, is placidly meaningless.

"Agricultural Enterprise in 1950" is the subject of the third picture. The artist has given expression to a dream in which a huge forcing house plays a prominent part. Crops are raised to an immense height by glass and by natural as well as by artificial light, while heat is obtained from vast systems of radiators. Storms are dissipated by the firing of mortars and shells. The artist depicts, as a means of generating power for the attainment of these wonderful objects, what is probably intended for a huge reciprocating engine driving a very cumbrous dynamo. Even now we have the steam turbine with us. Why the old reciprocating engine? So far as the idea of forcing plants by artificial lights is concerned, this is now done in many commercial gardens. Storms, too, are alleged to have been dissipated by the firing of mortars and shells. The picture, so far from being a glimpse into the future, belongs to the ever-living present.

"The Aerial Monorail" is the subject of the fourth illustration. The scientific prophet looks forward to electric traction on this system, which will achieve 150 miles an hour, and which is confessedly modeled after the famous Barmen-Elberfeld line. There is nothing very extraordinary in this, when it is considered the Berlin-Zossen road succeeded in whipping up the speed to 130 miles an hour.

SEEING AND FEELING AT A DISTANCE.

THE NEWSPAPER OF THE FUTURE.

AGRICULTURAL ENTERPRISE IN 1950.

FUTURE NIGHTMARE. THE AERIAL MONO-RAIL.

THE WORLD OF TO-MORROW: SOME DREAMS OF INVENTION RUN RIOT.

LIMITS OF SENSIBILITY OF ODORS AND EMANATIONS.*

THE discoveries daily made in the study of emanations give rise to an important question. What are the proportions of the substances manifested in this class of phenomena? Some who are interested in these problems are of opinion that it might be useful to compare these quantities with those manifested by odors, and with the limits of sensibility established in this respect by the tests that I have already published.

These experiments were made by examining the odor absorbed by the air contained in a gage of one cubic centimeter, isolated from every other vessel; that is to say, on an exactly defined volume of gas brought in contact with the olfactory organs, and itself containing an exactly known weight of odorous matter. In this class of tests it is indispensable to define strictly the two data of volume and weight experimented on.

If it is desired to render these data comparable with those in investigations on the emanations, it is suitable to keep account of the initial weight of the emanating substance, and of the gaseous volume in which it is distributed at the end of a given time, this volume being completely renewed at each operation of extraction of the emanation, when it is sought to exhaust this by means of distillation through tubes and faucets suitably disposed, that is, when working under the usual conditions of this class of operations.

This being premised, let us take an example from my experiments, that with iodoform, whose tenacious and penetrating odor and weak volatility are well known.

According to the exact measurements specified in my memoir, the limit of sensibility of the operator's olfactory organ approximated one-hundredth of a billionth of a gramme contained in a gage of one cubic centimeter of air. It was several hours before the odor, introduced into the center of a vessel, reached the extremity of the narrower tube, at the bottom of which the test gage was deposited. There was free circulation of air between the vessel, the tube, and the gage.

Let us now suppose an experiment made with iodoform under conditions analogous to those of the distillation of an emanating body; for instance, one gramme of substance deposited in a small space communicating by a distilling tube, having a faucet, with a receiver of 100 cubic centimeters' capacity in which the volatilized substance is collected. Let us suppose, for the sake of clearness, that an hour is necessary for this space to contain a quantity of the odorous matter susceptible of being manifested by the gage of a cubic centimeter; at the expiration of the hour the receiver is replaced by a similar one on which a second operation is made, and so on.

Under these conditions, a gramme of iodoform would lose a billionth of a gramme in an hour. By continuously repeating these operations for a year, it would lose $365 \times 24 = 8{,}760$ billionths of a gramme, or a little less than a hundredth of a milligramme. A century would be necessary for the gramme of substance to lose a milligramme. Had musk been employed, the weight lost would have been much less, perhaps a thousand times less, according to sundry estimates, which, however, were not as exact as the preceding.

I mention these figures solely for comparison, and to show how venturesome it would be to conclude as to the decomposition of a chemical element, from the appearance of certain properties in another element, such as spectroscopic characteristics.

Whatever otherwise may be the exactitude of this kind of measurements, their sensibility is of the order of that of the olfactory characteristics.

Extremely minute traces of foreign bodies contained in a principal mass consisting of one element, well defined, may be ascertained in this way without its being easy or even possible to exhaust the principal mass, even if it contained only a weight less than a thousandth part of these foreign bodies.

Estimation of the Fat in Milk.—This is accomplished by the Gottlieb-Roese process, introduced in Germany, by pouring 10 cubic centimeters of milk into a graduated test tube; then 1 cubic centimeter of ammonia, 10 cubic centimeters of alcohol, 25 cubic centimeters of ether, and 25 cubic centimeters of petroleum ether, boiling at a temperature below 60 deg. C. Afterward the mixture is shaken, allowed to stand for an hour, siphoned into a gaged flask, and rinsed out with ether. The solvent is distilled and weighed after desiccation of the fatty matter. The process is said to be more rapid, and at the same time more precise, than any other.

* From the French of M. Berthelot, Memoir to the Académie des Sciences.

DESERT PLANTS AS A SOURCE OF DRINKING WATER.*

By FREDERICK V. COVILLE.

A STRANGER left alone in a desert would die of thirst, and yet there is water in all deserts, and both the native animals and the native races know how to find it. This water is gathered and stored by plants, which have built and filled their reservoirs for their own purposes, but which yield it up, when required, for the use of the animal world.

The extent of the root system in desert plants, by means of which they absorb their water from the soil, is often astonishingly great. In the Mohave Desert of California a branching cactus (*Opuntia echinocarpa*) 48 centimeters (19 inches) in height was found to have a network of roots extending over an area of ground about 5.5 meters (18 feet) in diameter.† The roots lay near the surface, at a depth of 5 to 10 centimeters (2 to 4 inches), a situation which enabled them to take advantage of a single substantial downpour and, before the precipitation had been again absorbed into the parched air, to suck up a supply of water sufficient, if need be, for a whole year's use. Other desert plants send their roots deep into the ground for water, and a certain shrubby species of acacia found about Tucson, Arizona, possesses, according to Prof. R. H. Forbes, a double-root system, in which one series of roots spreads out horizontally, close beneath the surface, and a second series, sharply defined, goes directly downward into the soil. Such an arrangement enables the plant to seize upon water either from light precipitation or when deeply percolating under dry stream beds.

While the devices for absorption in desert plants are unusual, the mechanical contrivances by means of which these plants are enabled to retain the moisture they have absorbed are still more remarkable. Other factors being equal, the amount of water transpired, or evaporated, from a plant is proportional to the area of its green surface, which, in ordinary plants, is a foliage surface. A specimen of coffee plant (*Coffea arabica*) weighing 20.5 grammes is found to have a leaf surface computed at 164,476 square millimeters, which gives a ratio of 1 to 8,023. A specimen of bisnaga or barrel cactus (*Echinocactus emoryi*), in the conservatories of the Department of Agriculture at Washington, weighing 77,000 grammes (170 pounds) and without leaves, has a green stem surface of 1,032,320 square millimeters, with a ratio of 1 to 13.4 (Fig. 1). Thus for each gramme of tissue a coffee plant, representing the ordinary vegetation of a humid climate, has a green surface 599 times greater than that representing a gramme of tissue in cactus; or in physiological terms, the coffee plant, other factors being equal, is provided with means for the transpiration of 600 times as much water as the cactus.

Not only is the green surface of desert plants very much restricted in extent, but it has such a structure as greatly to reduce the amount of moisture transpired through it. The structure of an ordinary transpiration pore in a plant of humid habitat is shown in Fig. 2. Through the courtesy of Dr. R. E. B. McKenney the structure of a pore of *Echinocactus emoryi* is presented for comparison (Fig. 3). It is to be noted that the cuticle of the latter is excessively thickened. Beneath the epidermis is a deep layer of hypodermis with very thick walled cells and small cell cavities. It can scarcely be doubted that, except at the pores, the epidermal structure is impervious to moisture even under the extreme desiccating conditions of the desert. Beneath the minute opening of the pore is an air chamber, the lower contracted end of which is made up of the walls of the green, moist interior cells of the plant. The portion of the walls of this chamber which lie within the hypodermis, Dr. McKenney has discovered, are cutinized, so as to be impervious to moisture. The cushion of air in the chamber is therefore slowly receiving moisture at its lower end from the interior water supply of the plant and slowly giving it off into the outer air whenever the two guard cells open the narrow slit between them. The whole structure is evidently well adapted to the maintenance of a transpiration current at an exceedingly attenuated rate adapted to the plant's limited supply of moisture.

The interior of the plant consists chiefly of water-storage cells (Fig. 4). These are globular in form, devoid of green coloring matter, and with walls somewhat thickened but possessing thinner sieve-plate areas which permit the ready transfer of water from one cell to another throughout the interior. Dr. McKenney has made a determination of the water in a sample of this storage tissue and finds the astonishing amount, by weight, of 96.3 per cent. The plant when filled to its capacity is almost a tank of water.

That animals which live in a desert would have difficulty in securing a regular supply of water is evident. But it is a matter of fact that many of these animals go without water for months at a time, deriving all their moisture from the watery tissues of plants; and there is conclusive evidence that some animals never drink water, apparently not knowing what water is, and never eat even ordinary herbage, but subsist on dry seeds alone. D. W. Carnegie records the statement* that while traveling across the desert of southwestern Australia, his band of nine camels went without water from July 29 to August 10, 1896, a period of 12 days, on the latter date taking a full drink averaging 17 gallons each; while two of his camels performed a still more wonderful feat of abstinence in traveling for a period of thirty-seven days, from August 22 to September 28, 1896, on only 13 gallons of water each, which they drank as follows: August 29, after seven days, 2 gallons; September 8, after ten days more, 8 gallons; September 18, after an additional ten days, 3 gallons. Bands of Merino sheep grazing on the tender annual vegetation that springs up on the desert near Phoenix, Arizona, after the winter rains, sometimes drink no water for a period of forty to sixty days. In the desert plain of Sonora, Mexico, west of the railroad station of Torres, are isolated rocky hills in which peccaries live for months at a time without possible access to natural water. It is evident from their habit of rooting in the ground like the domestic hog, that they derive some of their requisite moisture from the underground portions of plants, while another source of moisture is the fruit of opuntia and other cactuses.

Mr. T. S. Van Dyke, in an article on the mule deer,* says:

"When on this food [cactus] deer not only can go without water, but often go without it when it is perfectly convenient. On the great Mexican desert known as the Bolson de Mapimi, I hunted for several weeks in 1884, stopping at a railroad station 25 miles from anywhere, and known to be 25 miles from any other water. Several hundred feet from the station the leakage from the water cars of the railroad made a shallow pond some 50 feet long and a dozen wide. To the leeward of this fresh tracks of deer could be found almost any morning, all near enough to smell the water, but not one of them going to it. I had plenty of other most positive proof that the deer there, as well as the antelope, did not go to water, though the days were hot enough to make a man want water as much as in midsummer. For many a league there was no green feed except some of the varieties of cactus, and every deer and antelope that I opened in this vicinity was filled with it. The same is true in parts of Sonora and in much of Lower California."

This statement is confirmed by Mr. E. W. Nelson, the American naturalist most widely experienced in Mexican travel and observation, to whom similar instances are well known.

Various authentic records exist regarding the almost incredible abstinence of some of the small desert rodents of the southwestern United States. Mr. Vernon Bailey, of the United States Biological Survey, informs me that he kept a desert jumping mouse (*Microdipodops megacephalus*) for more than a month, during which period it ate only dry seeds and grain. After it had become very tame he placed water before it, but it would not drink. When the dish was elevated until the water touched the end of its nose, the animal showed every sign of ignorance of the liquid and even repugnance to it. Mr. F. Stephens, of Santa Ysabel, California, has recorded the statement† that he had a pet of the gray pocket mouse (*Perognathus fallax*) which drank no water in the six months during which it had been in his possession; that it would not touch water, and did not seem to know what water was, and that it would not eat green food. He states also that Mr. W. G. Wright, of San Bernardino, California, had a captive specimen of the tuft-tailed pocket mouse (*Perognathus penicillatus*) which had no drink and no food save dry grain for more than two years. Dr. J. A. Allen, of the American Museum of Natural History, states‡ that a pocket mouse from western Texas (*Perognathus merriami*) had been kept for nearly three years without water, his food during that period consisting exclusively of dry mixed birdseed. The domicile of the animal was a tin box 10 by 20 by 14 inches,

PAPAGO INDIAN DRINKING FROM A BISNAGA (ECHINOCACTUS EMORYI).

PAPAGO INDIAN PREPARING A BISNAGA (ECHINOCACTUS EMORYI).

* Reprinted from Smithsonian Institution Report.

† Coville, Contributions from the United States National Herbarium Vol. iv. (Botany of the Death Valley Expedition), pp. 46-7, 1893.

* D. W. Carnegie, Spinifex and Sand, pp. 194, 361. 1898.

* In "The Deer Family," by Theodore Roosevelt and others, pp. 193-194, 1902.

† West American Scientist, vol. vii., p. 38, 1890.

‡ Bulletin of the American Museum of National History, vol. viii., p. 58, 1896; American Naturalist, vol. xxxii., pp. 583-584, 1898.

open at the top, but with a thick layer of earth at the bottom. Dr. Allen summarized his experience with the animal in the statement, "As no water and no fresh vegetation have been given him for nearly three years, it is evident that the only moisture required for his sustenance is derived wholly from dry birdseed." A water content determination of dry mixed birdseed, made in Washington, December 31, 1903, shows 11.75 per cent of moisture. Freshly matured wheat grains in the climate of the arid portions of California have a water content of only 6 to 8 per cent of their weight. It is impossible that these rodents, performing their functions of respiration, digestion, and secretion, can subsist on this amount of moisture. The subject is one that deserves precise quantitative measurement as well as anatomical investigation. Is it possible that

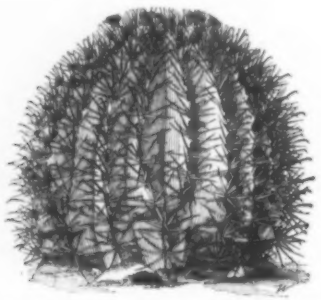


FIG. 1.—BISNAGA OR BARREL CACTUS (ECHINOCACTUS EMORYI.)

One-ninth natural size.

these animals possess some apparatus by means of which they can abstract moisture from the air hygroscopically and condense it for their own use? Or do they manufacture the water they require by the chemical dissolution of starch?

However this may be, it is clear from some of the cases cited that the water supply of many desert animals, either for long periods or during their whole lives, comes not from natural water, but from that stored in the tissues of plants. It is an old established fact that animals do not possess the power to manufacture their food out of the raw mineral constituents of the soil, but that these constituents must first be elaborated into starch or other food products by plants. To this fundamental dependence of animal upon vegetable life may be added, in the case of many desert animals, their further complete dependence on plants for their supply of water.

Under certain conditions this dependence of desert animals upon plants for their water is extended even to the human race. The rainfall of the desert of Sonora is so small and so irregularly timed that periods of prolonged drought occur, during which many of the customary sources of water supply, always few and far between, fail utterly. To two of the native tribes, the Seris and Papagos, such a condition is not necessarily serious, for they betake themselves to the water stored in cactuses.

Some of the largest cactuses, such as the saguaro, or giant cactus (*Cereus giganteus*), the pitahaya (*Cereus thurberi*), and the sina (*Pilocereus schottii*), are not available as a source of drinking water, for their juice is bitter and nauseating. But the juice of certain species of the genus Echinocactus, notably *E. emoryi* and *E. wislizeni*, is sweet and palatable. These cactuses, the Mexican name of which is bisnaga, are known by all natives of the desert region as a potential source of drinking water. In February, 1903, the writer, in company with Dr. D. T. MacDougal, while seeking a location for a desert botanical laboratory for the Carnegie Institution, found an opportunity to observe the extraction of water from a bisnaga according to the primitive process and by one of the aborigines themselves.

FIG. 2.—TRANSPIRATION PORE OF TRADESCANTIA VIRGINICA.

a, Epidermis; *b*, outer wall of epidermal cell; *d*, cavity of epidermic cell; *f*, green interior tissue; *g*, guard cells of the transpiration pore; *h*, transpiration chamber. Much enlarged. After Strasburger.

The locality was in the State of Sonora, Mexico, at a point about 12 kilometers (8 miles) west of the railroad station of Torres. Upon request a Papago Indian, the guide of the party, exhibited the operation. The cactus used was a specimen of bisnaga (*Echinocactus emoryi*) with which the region abounds.

The plant selected was about 1 meter (3 1-3 feet) high and 0.5 meter (20 inches) in diameter. Its top was first sliced off, exposing the white interior. It was evident that this was saturated with water, but the structure of the tissue was such that the water did not exude of its own accord. The Indian cut a stake of palo verde (*Parkinsonia microphylla*) about 7.5 centimeters (3 inches) in diameter at the larger and blunt end, and with this proceeded to mash the white flesh of the cactus into a pulp. As the churning progressed a bowl was formed in the top of the cactus, and when a suitable quantity of pulp had accumulated in it the Indian, taking this up handful by handful, squeezed out the water into the bowl, throwing the rejected pulp upon the ground.

From the upper 20 centimeters (about 8 inches) of the cactus about 3 liters (3 quarts) of water was obtained. Its flavor may be described as very slightly salty and somewhat herbaceous. Any really thirsty traveler would have drunk it without hesitation, and our Papago, although he had had plenty of water from

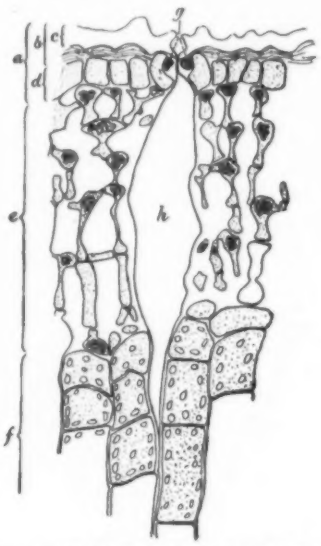


FIG. 3.—TRANSPIRATION PORE OF ECHINOCACTUS EMORYI.

a, Epidermis; *b*, outer wall of epidermal cell; *c*, cuticle; *d*, cavity of epidermal cell; *e*, hypodermis; *f*, green interior tissue; *g*, guard cells of the transpiration pore; *h*, transpiration chamber. Much enlarged. After McKenney.

the supply we carried, drank the cactus juice with evident pleasure.

A bisnaga of approximately spherical form furnishes a more palatable water than the cylindrical specimens many years older, and care is taken to use for a masher a wood which has no bitter, resinous, or poisonous qualities. No deleterious effect is caused, our Indian stated, through drinking a quantity of the water, unless one subjects himself immediately afterward to violent physical exercise. The natives use the cactus water, if need be, for mixing bread, and evidently it could be devoted to any camp use.

An interesting correlation is to be noted between the palatable flesh of the bisnagas and their effective protection against grazing animals through their impenetrable armor of hooked and rigid spines. Without such protection the bisnaga would be doomed to early extinction by such animals as required a continual supply of moist, herbaceous food. Other cactuses, on the contrary, which have a bitter and nauseating juice, often have only a very imperfect protection by spines, as the giant cactus (*Cereus giganteus*) and the sina (*Pilocereus schottii*). One cactus, the peyote (*Lophophora williamsii*), has no spines whatever at maturity. In appearance it is as plump and juicy as an apple; yet, as is demonstrated by its abundance in certain localities, it is amply protected against the depredations of animals by its bitter and poisonous juice.

Another notable feature in the mechanical construction of the bisnaga is the fluted character of its surface. Between the times when its body is fully distended with water from the absorption following a heavy rain and other times when its interior tissues are

FIG. 4.—WATER STORAGE TISSUE OF ECHINOCACTUS EMORYI.

a, Water storage cells; *b*, intercellular spaces; *c*, sieve plates, face view; *d*, sieve plates, in cross section. After McKenney.

far shrunken after a prolonged drought, the plant, if ordinarily constructed, would be very liable, from the repeated wrinkling and stretching of its hard skin, to injury by cracking. What form could be more admirably suited to accommodate the bisnaga to this feature of its existence than the fluting of its surface, each fluting or rib becoming thick by the absorption of water and thin by its loss?

Strenuous are the conditions to which the plants of the desert are doomed; many and remarkable are the devices with which these conditions are met, and rich are the opportunities for research where such phenomena exist. It is a matter for congratulation that to the United States belongs the credit of first establishing a botanical laboratory in the midst of the desert. Such a laboratory has been founded near Tucson, Arizona, by the Carnegie Institution of Washington, and we may confidently expect to learn from time to time of results which shall excite our wonder and which shall constitute new contributions to the sum of human knowledge.

ROTARY ENGINES.

THERE are certain problems in mechanical engineering which appear to be always on the point of being solved, and always evading solution. Frequently they offer to the inventor a selection of many methods, and they are invariably of obvious desirability. Moreover, they have the fascinating characteristic that success always seems just within reach. One of these problems is the rotary engine. We hesitate to say what a huge number of inventions of engines of this description have been protected since patent laws began. It certainly runs into three figures, and our own patent office alone, we are confident from a rapid review of the lists of specifications for a few weeks here and there during recent years, must receive at least fifty applications, and probably many more, every twelve months. One very remarkable fact about the invention of the rotary engine is that it never ceases, and that the inventor of to-day never profits by the lessons of his predecessors. Reuleaux, in his classical work—he himself, by the way, if we remember rightly, believed the problem to be solvable—has arranged all types of rotary engines in a number of classes, and has given diagrammatic sketches of representatives of each type. We believe that, although his book is many years old, not a single new type could now be added to Reuleaux's list. Invention keeps going over and over the same old ground, sometimes without any attempt to meet the real difficulties of the problem, and sometimes with full recognition of the obstacles to success and praiseworthy efforts to overcome them. Yet the result is always the same. For a time a rotary engine, here and there, designed better than others, has a short life; but they all, without exception, have hitherto disappeared after a few years into the limbo of history or into an intermediate condition of insignificance.

Years ago, before it was found that reciprocating engines could be run at very high speeds with success and efficiency, the rotary engine received more scientific attention than it does to-day; but since the stream of inventions runs as full as ever, it may be that some of our younger engineers have forgotten the few elementary facts that stand in the way of success. They are true of by far the greater number of designs. The first is the line contact, the second excessive clearance, the third friction produced by unbalanced steam pressure, or centrifugal force, on moving parts. If anyone will look at a number of diagrams of rotary engines he will see that a favorite design is the "crescent chamber type." In this engine one cylinder is placed eccentrically inside another, and is provided with radial abutments of some form or another. In some cases the inner cylinder makes one of the abutments by bearing against the walls of the containing-cylinder. The contact between two curved surfaces of different radii is a line contact, and steam-tightness is impossible. That is an elementary fact which is daily forgotten. In some designs the abutments spring from the center of the inner cylinder: hence they are only radial to the outer cylinder in two positions, and, if their extremities are curved to fit the outer walls in these positions they will fit nowhere else; hence, if line contact is to be avoided, a flexible joint of some kind, with consequent leakage and complication, must be employed. If in an endeavor to avoid the first difficulty the inner cylinder is removed some distance from the outer casing, and the changes in the contents between two radial abutments looked to for the propelling power, the clearance at once becomes formidable. The designer therefore finds himself in a quandary. In the one case he loses steam by leakage, in the other by excessive clearance. In another common type of engine abutments are hinged either on the rotating members or on the fixed cylinder; if the former, they are driven out with considerable centrifugal force, if the latter, they are pressed in by the steam, frictional loss increasing in either case to an enormous extent unless provision, again with necessary complications, for removing these objections is introduced. Again, there is the common type in which the revolving portion is cam-shaped, and an abutment either presses on it radially or obliquely. In either case one of two, or both, of the following difficulties have to be met—either the back of the projection is nearly radial, in which case, however quickly the abutment may fall, it cannot prevent clearance being excessive, or the projection may be curved and closely followed by the abutment remaining always in touch with it, when, again, it is difficult in practice, owing to the curvature of the abutment, to avoid line contact, as a few moments' consideration will show.

All older engineers who have studied the question at all are aware of these difficulties, and have long since given up the pursuit; but younger men, even among engineers, still spend their guineas year after year in the vain quest, and it is to them that these few remarks on one or two out of the many difficulties that beset the rotary engine are addressed. We have touched only two or three types, but we invite our inventors to study Reuleaux's pages, and to apply his lucid critical observations to their devices before they take out patents. One very important thing they must note, and that is that many rotary engines are reciprocating engines in disguise, having masses with alternating motions just as ordinary engines have, and

hence lacking the very advantages supposed to be given by the rotary type.—The Engineer.

CANDLES, OLD AND NEW.*

THE most prosaic things will often be found upon examination to have had at some time much romance hanging around them, and even such an ordinary article of domestic use as a candle has a most interesting past. At a very early period in the history of mankind fire and light were invested with celestial attributes, and the candle especially has been associated with worship even up to the present day. It is not surprising that this should be the case, for the burning of a candle, until the foundation of modern chemistry, must have presented a great mystery. A solid substance is seen in it to gradually disappear, to evaporate, while at the same time light, which is naturally associated with life and all that makes life worth living, is created. The candle is the emblem of the grosser part of matter changing to the ethereal, and it has taken part in religious festivals all the world over for untold ages.

It is impossible to say at what date candles were first used. There are many scriptural references to them; but the words "candle," "candlestick," and "lamp" are used indiscriminately in our translation of the Bible, so that we cannot differentiate the one from the others. A Latin author, Apuleius, shows that in his time (A. D. 174) candles of wax and tallow, torches of pine, and lamps were all in use; before that Pliny had recorded that the Romans used wax candles in certain sacred rites; and we now know that at Herculaneum has been found the apparatus of a chandler's shop.

We may be sure that the candle, like other things, was the subject of slow evolution, and its parent was undoubtedly the torch—a mere splinter of pine wood with resin oozing from its pores. Then would follow the link, a better sort of torch, consisting of rope covered with pitch or resin. Middle-aged Londoners can remember that such torches were sold in the metropolitan streets on foggy days when the thoroughfares were not so brilliantly illuminated as they are now. Going back still farther into London's chequered history, we are reminded by the huge extinguishers which still protrude from the ironwork surrounding some of the old doorways, that footmen and link-boys ran with torches in front of the carriages of the well-to-do—a necessary precaution at a time when the streets were dimly lighted by oil-lamps.

Next came the flambeau, a superior sort of torch, which had a central core of oakum surrounded by layers of resin and crude beeswax. Here we certainly have the germ of the candle, if it had not long before been suggested by the accident of grease from some cooking operation flowing over and coating the sticks which served for fuel. Tallow and beeswax are two natural substances which present themselves for candle-making, one for the use of the poor and the other for the rich. Time was, indeed, when a man's social status might be gaged by the material of which his candles were composed. The convenient and highly decorative electric glow-lamp has ousted the wax candle, and it would be difficult to find a house where wax is now used.

As a matter of interest it may be mentioned that one of the last public places in London which was lighted by pure wax tapers was the Chapel Royal, St. James's Palace. These candles, which were about a foot in length, were used for the Sunday evening service, lasting forty-five minutes, and were never used twice. The scarcely shortened candles became the perquisite of the chapel officials, and even the members of the choir carried away their particular tapers after service.

Like all other manufactures, that of candles began in a humble way—they were made by hand in that hap-hazard, unscientific manner which is commonly expressed by the term "rule of thumb." Reference to the pages of an encyclopedia which bears date 1819 will show us in a moment how candles were made at that date. We are told there that a candle consists of a cotton or linen wick loosely twisted and covered with tallow, wax, or spermaceti; that a good candle should consist of an equal mixture of bullock's tallow and sheep's tallow; that the fat of hogs will make a candle gutter, and will make it emit a black smoke and an evil smell. Then we are instructed in the method of making the candle, and are told how the tallow, having been melted, is allowed to stand for a few hours to settle, after which the wicks are immersed again and again until the candle grows to the required thickness.

Wax candles—which, we read, were chiefly used for churches, processions, funeral ceremonies, and the like—were made differently. Melted wax was poured from a ladle on to the suspended wicks, until the candles grew to the necessary thickness; they were then transferred to a "feather bed" to keep them warm, and were subsequently rolled to form on a flat table.

It will thus be seen that very little science entered into the business of candle-making up to the second decade of the last century. But a clever French chemist, Chevreul by name, had for some years been working in his laboratory with a view to determine the nature of fatty bodies. He gave his results to the world in the year 1823, and earned the title of "the father of the fatty acids;" for he showed that all the neutral fats of commerce, such as tallow, coco-nut oil, cotton-seed oil, and many kinds of grease, were not simple organic substances, as had been previously supposed, but were fatty acids in combination with glycerine. Glycerine, it may be remarked, was discovered by the Swedish chemist Scheele in 1779, who called it "the sweet principle of fats."

The researches of Chevreul placed the manufacture of candles upon an entirely new basis, and "rule of thumb" had to give way to "rule of head." He showed that by separating the glycerine from the fats, the substance left, now known commercially as stearine, was not only firmer and whiter than the original fat, but was in every way better adapted to candle-making. Moreover, the glycerine, once regarded as a waste-product, has since become highly esteemed as a valuable aid in medicine and in the arts. An attempt was made by Chevreul himself, in partnership with Gay-Lussac, to start a candle-factory under the new conditions; but the enterprise failed, and the first to succeed in the work was a Frenchman, M. de Milly, who, by a modification of Chevreul's methods, placed stearic acid candles on the Parisian market which were priced at two francs per pound. From this it may be judged that the new process, however efficient it may have been, was by no means cheap in execution.

No great advance took place for the next two decades; but in 1842 we find several English chemists at work upon the problem of producing fatty acids from cheaper materials than tallow. It was found that sulphuric acid acted as a decolorizer and deodorizer of dark and strongly smelling fats; so that from the most nauseous and unpromising materials—bone and skin fats, and malodorous grease of all kinds—a firm, white, inodorous material could be obtained at a moderate price, and thus was laid the foundation of a big industry. The "stearine" or composite candle soon became known throughout the world, and was without a rival until the year 1850, when paraffin-wax came within reach of the candle manufacturer. This beautifully white solid substance, somewhat like spermaceti in appearance, was originally obtained from the distillation of coal, but later from petroleum. It is now produced in large quantities in the United States, in Scotland (from shale), and in Burma, the total yearly output being estimated at not less than one hundred and twenty thousand tons. Much of this finds its way to the candle-factories; and although paraffin is too soft by itself for candles—especially those intended for warm climates—when it is mixed with stearine in certain proportions an excellent material is obtained. Such candles are known as "paraffin composites," and the material is also largely used for the making of "night-lights."

There are persons now alive who can well remember the time when the "snuffers" and "snuffer-tray" were regularly placed upon a dinner-table by the side of the candles, and unless those candles were snuffed at frequent intervals they smoked and emitted a nasty smell. This was obviated by the introduction of the plaited wick, a wick so made that it had a tendency to bend outward, so that it met the air on the borders of the flame and was completely consumed. In the evolution of the perfect candle, as much attention has been paid to the nature and material of the wick as to the composition surrounding it.

Many of us will be apt to think that, because in our cities and towns we see the streets and shops brilliantly lighted by gas and electricity, the candle manufacture is doomed, and that in the near future candles will be seen only in museums as interesting relics of the past. We are all influenced by our environment, and because we may happen to dwell in some busy center where more modern methods of artificial illumination prevail, we lose sight of the circumstance that there are still in all lands hundreds and thousands of towns and villages where gas and electricity are unknown, and where candles are still largely used. And let it be remembered that a candle, so far as it goes, is a most convenient light-giver. It is a veritable gas-works in itself, with the power of turning into inflammable vapor the solid matter of which it is composed, without the help of pipes, retorts, purifiers, or other cumbrous plant. It is certainly the most self-contained of all artificial illuminants, and in spite of the coming of more brilliant rivals it will certainly hold its own for a long time to come.

If any one has doubts as to the present popularity of candles, he would do well to visit one of the large factories where they are made, when he would get some idea of the present daily output of these light-givers. Such a visit the present writer lately paid to the works of Messrs. Price & Company, Battersea, London, which cover an area of eleven acres, and may be regarded as the finest factories devoted to this industry in the world. It is only fair to state that most of the important improvements in the making of candles have been discovered and carried out in this busy factory on the banks of the Thames. The company have established another factory at Liverpool, the port to which the palm-oil comes, where that product is treated for candle-making; but to the premises at Battersea we must confine our attention.

Although most of the candles we see used are molded, the old dipping process is still employed, and here we can see it in full operation. The "dip" is too convenient a form of light to be given up, and seems to be preferred to any other kind of illuminant by certain craftsmen. One reason for this is that its broad wick gives a good flame which is not easily blown out by a passing gust of wind. The cobbler likes to work by the light of a "dip"; so does the miner, who finds that it will stick in any crevice in the wall, or in his hat, as no other light-giver will. So the "dip" is still made in huge quantities, while its quality is improved by the substitution of stearine for the raw tallow previously employed.

But to watch the manufacture of candles of the better sort we must proceed to another department. Here is a vast hall full of steaming vats containing a mixture of stearine and paraffin. We see these two solids being brought in trucks to the side of the vats and placed therein in certain proportions; then the steam is turned on, and they are left to melt and combine. Later on, the hot liquid is drawn off into tanks on wheels, and is taken to the candle-molding room.

The candle-machine is a most ingenious apparatus, but difficult to describe. It consists of about one hundred metal tubes or molds arranged in rows in a casting-box. Below each tube is a reel of wick, and this wick is held rigidly in its center. The tender of the machine comes along with a large can of melted composition, which he empties into the casting-box, thus filling all the molds at once; then he turns a tap which causes water to circulate round all the tubes, so that their contents quickly become solid. A crank is then turned, and the candles are pushed up from the molds, the wicks depending from their ends. The molds are now ready to receive a fresh charge of composition, the candles above serving as wick-holders for the new batch of candles. When these latter are ready for raising, the wicks of the first lot are cut off and the candles removed to the packing-room. And so the work of candle-making goes on unceasingly and at a prodigious rate. Let it be noted that this is a brief description of the making of only one kind of candle in a factory where many different sorts are manufactured: twisted candles, fluted candles, giant candles for altar use, scented candles, painted candles, and stained candles. Among the last we noted with interest some bright-scarlet light-givers which were destined for the Chinese "feast of lanterns."

There is so much to be seen in this huge and busy hive that we cannot stop long in one department. The cardboard box and night-light case-making room, where the deft fingers of dozens of girls work with lightning speed, claims our attention for a moment, and we presently see how the cases are fitted with wicks and subsequently with their blocks of composition. There is also a variety in night-lights, and as much care has been expended upon perfecting their composition and their wicks as in the case of candles.

Candle-making and soap-making are industries so nearly allied that they go hand-in-hand, and at Battersea a large area is given up to soap. It would take us too far from our subject to deal with this part of the factory, which in itself is full of interest. We have been obliged to confine our attention to candles, and, as it is, have but touched the fringe of a very large subject, for the London Directory alone has a list of over thirty candle-makers. Prominent in the list are other famous makers, such as J. C. & J. Field (Limited), manufacturers of ozokerit and self-fitting candles; the Broxburn Oil Company; and Young's Paraffin Light Company. In spite of the introduction of gas, of the cheap paraffin-lamp, and later on of electricity, candles are plentifully used all the world over, and not a few of them are made at Battersea.

*Chambers's Journal.

THE VENETIAN SILKWORM INDUSTRY.

SOME interesting details concerning the Venetian silkworm industry, together with the results of the experiments that have been made for preserving the cocoons, are contained in a British consular report. The yield of cocoons during 1904 was plentiful. Owing to favorable atmospheric conditions the produce of the eggs was exceedingly abundant. The worms were free from all disease at the moment of going to spin their cocoons, which is done within branches of plants and furze called a "bosco." At Mantua and other neighboring provinces the "bosco" comprises a plant called *ravizzone*, which apparently is preferred by the worms, on account of its odor and oily bark. The prevalent species are common cross yellow, crossed Japanese, and Chinese breeds.

Great progress has lately been made in these provinces in adopting scientific methods of treating the worms, which are very liable to be attacked by vermin and disease. When the worm is young, the leaves of the mulberry tree are sliced in small strips and scattered over the trays. When the worm is more advanced, it can be fed upon leaves as taken from the tree. The waste and fibers of leaves unconsumed are carefully removed, and great care taken to make the worm comfortable and clean, and to insure a regular temperature as far as may be practicable, as cold or too much exposure to the sun is liable to cause its death. Worms have to be fed day and night, at regular short intervals, until they are mature.

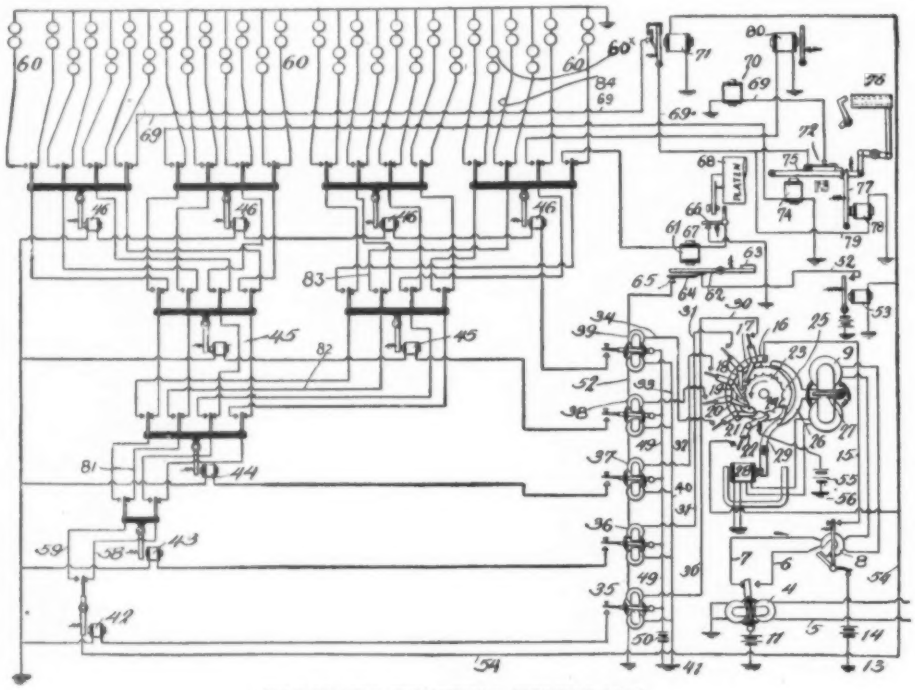
During the past year experiments have been carried out with the object of preserving cocoons by laying them in cold stores, after being placed in sealed straw boxes. The beneficial effect of cold on the eggs was already known, as the peasants are in the habit of burying them in summer time under snow or ice in the mountains. But this is the first time that an experiment has been made on cocoons. The point to be ascertained was whether the moths were killed by a cold atmosphere. Having chosen a quantity of cocoons, they were divided into two groups, one of which was placed in the cold stores kept at freezing point, and the other in the drying stoves constructed by Bianchi and Dublini. The cocoons were preserved in the cold stores from June 24 to September 24, one portion of such cocoons being enveloped in paper and the other in gauze, and then placed in closed straw baskets. When they were taken out, it was found that the chrysalis was entirely killed,

without any decomposition or alteration of the cocoons, although their toughness had decreased from the effect of damp, but after a short exposure in the open air they dried up completely.

Two different samples of cocoons were then sent to the "Stabilimento delle Sete" in Milan, and on comparing 1,000 meters of the two kinds when thrown, it was found that the cocoons dried in the stoves yielded a shorter thread, with more breaks in the filament; the quality of the silk also told in favor of the cold storage system. From these results it would appear that the principal points to be ascertained are the exact number of days for which the cocoons are to be kept in the cold stores in order that the chrysalides may be killed, and whether it is economically advantageous to adopt the new process.

BARCLAY'S PRINTING TELEGRAPH.*

MACHINE-PRINTING telegraph systems are destined in the opinion of many to play a conspicuous if not a dominant part in the telegraph of the future. The subject was one which attracted attention at the recent International Electrical Congress in St. Louis, and several good papers were read at that time. One of these was by John C. Barclay of New York, in which he described the most fruitful attempts which had been made up to that time in this line of work. It was known at the time that Mr. Barclay himself had near completion a system of this character which was expected to bring forth some new developments. In the latter part of December considerable space was given in the daily newspapers to the remarkable results which had been attained by a series of tests with a system of printing telegraphy invented by Mr. Barclay, who is assistant general manager of the Western Union Telegraph Company, and which operated with a marked degree of success. At that time a thorough technical description of the apparatus was unavailable. A patent was, however, issued to Mr. Barclay on March 21, the application having been filed March 1, 1904, for improvements on such a system which in all probability covers the latest developments in the invention upon which he has been working for a considerable time, and the success of which was demonstrated some months ago. The following description of the apparatus as embodied in the patent specification will be of interest:



BARCLAY'S PRINTING TELEGRAPH.

For the transmission of the messages successions of current pulses are used which are the same in number for all the characters, but vary in length. These pulses are usually, but not necessarily, alternately of opposite directions. For transmitting the characters of the English alphabet there are employed six pulses for each message or character, which enables the operation at will of any one of the 32 magnets, thus permitting the transmission of all the letters of the alphabet, and leaving a margin for transmission of punctuation marks and for the operation of spacing, carriage return, shift and paper-feed mechanism. The particular magnet corresponding to each message transmitted is selected by the action of primary and secondary selecting relays, a sunflower, and a separator relay.

The invention consists in closing the circuit through contact points of the selecting relays to the printing magnet selected through a contact of the sunflower itself, in delaying completion of the restoring circuit during the operation of the carriage-return mechanism until the carriage has returned to its starting point, in improved means for operating the spacing mechanism without the operation of the selecting relays, and in improved shift mechanism.

Referring to the accompanying diagram, signals incoming over the line wire (5) actuate a main-line relay (4), which is the primary actuating element of the printing telegraph, and is the only element of the telegraph in the main-line circuit. This main-line relay may of course be differentially wound to permit of duplex or quadruplex operation the same as an ordinary main-line telegraph relay. The main-line signals for operating this relay may be produced by a hand key or by a keyboard transmitter or by any other suitable means. This particular line relay is of the polar type, being arranged to be actuated by changes of direction of current in the line circuit. Obviously it may be a neutral relay instead, arranged to be operated by rise and fall of the line current. Main-line relay (4) controls two local circuits (6) and (7), connected to opposing contact points of the main-line relay, both of which circuits pass through coils of a neutral relay (8), termed the "separator relay," through opposing coils of a magnet (9), operating escapement mechanism of the sunflower, and through a synchronizer magnet (28) to ground at (10). A battery (11) or other suitable source of electrical energy is connected to ground and to the armature of main-line relay. One or the other of circuits (6) and (7) is completed through battery (11), according as the armature of relay (4) is in contact with the right-hand or left-hand contact of the relay. The main-line relay is very rapid in action and operates for each pulse produced in the main line, whether short or long. The separator relay is more sluggish in action, and completes the circuit which it controls only when a long pulse is sent over the line. Being a neutral relay, however, it completes its circuit each time there is a long pulse, whether it be positive or negative. The circuit controlled by separator relay (8) passes from ground at (13) through battery (14), the armature of the separator relay and conductor (15) to a plate (16) of the sunflower, to which the first five contact points (17), (18), (19), (20) and (21) of the sunflower are electrically connected. This sunflower is of the type described in the patent issued to Buckingham, dated August 18, 1895, and consists of contact points (17), (18), (19), (20), (21) and (22), adapted to be actuated successively by teeth of a ratchet wheel (23) during movement of the wheel through the space of one tooth. The ratchet wheel is mounted upon a shaft (24), upon which is also mounted an escapement wheel (25), having three times the number of teeth of ratchet wheel (23) and controlled in its movement by the escapement anchor (26), which is actuated by the armature (27), which is polarized. The coils of magnet (9), through which circuits (6) and (7) pass, being oppositely wound, alternate pulses in these circuits will cause the vibration of the escapement anchor (26), and six such pulses, permitting rotation of escapement wheel (25) through the space of three teeth, will advance ratchet wheel (23) through the space of one tooth, causing contact points (17) to (22) to complete their respective contacts successively and completing one cycle operation of the sunflower. The shaft (24) of the sunflower is driven by any suitable device, such as a spring motor or friction drive, which will permit intermittent motion of the shaft. Magnet (28) beneath the sunflower is a synchronizer magnet operating an armature lever (29), having a hook adapted to engage the teeth of ratchet wheel (23).

It was stated above that the metal frame (16) carrying contact points (17) to (21) is connected by conductor (15), passing through contacts of separator relay (8), with battery (14) and thence to ground. These contact points (17) to (21), inclusive, which may be termed "selector contacts," when operated by the movement of ratchet wheel (23) complete circuits successively from the contact points of separator relay (8) through conductors (30) to (34), respectively, leading to the magnets of polar-selecting relays (35), (36), (37), (38) and (39), respectively, and thence through a common-return conductor (40) to ground at (41); but it will be seen that none of these circuits through the magnets of the polar-selecting relays will be closed unless at the instant when any one of those circuits is closed through the sunflower the transmission of a long-pulse through the line has caused the separator relay to complete the circuit through battery (14) to ground at (13). Polar-selecting relays (35) to (39), inclusive, control circuits of secondary selecting relays (42) to (46), respectively, the contact points of which are connected in tandem in the order named, the five series of contact points forming an arithmetical progression. In the present system are illustrated the employment of an alternative and equivalent construction involving the mounting of a number of contact points on the relay armatures so that there is but one relay (43), one relay (44), two relays (45), and four relays (46), each of the relays (44), (45) and (46) having four contact points.

The primary selecting relays (35) to (39), inclusive, each controls a circuit of a corresponding secondary selecting relay or relays. The controlling circuits of these secondary selecting relays (42) to (46), inclusive, are normally broken; but the armatures of the several primary selecting relays are connected by a multiple-current lead (49) to a battery (50) and to ground, and when the magnet of any one polar-selecting relay is energized by a current passing through the sunflower, and its armature is deflected, the polar-selecting relay completes the circuit through the corresponding secondary selecting relay or relays which it controls, thereby operating them. The armatures of the primary or polar-selecting relays (35) to (39) tend to remain in contact with whatever contact point they are in contact with at the time. These relays are provided with a second or restoring circuit (52), passing in series through all of these relays, which circuit when completed by a restoring relay returns the armatures of all these relays to their normal positions, breaking the circuits of the secondary selecting relays (42) to (46). This restoring circuit is arranged to be completed by a restoring relay (53) after circuit is completed through the sixth contact piece (22) of the sunflower.

Referring now to the secondary selecting relays (42) to (46), the armature of relay (42) is connected to a circuit (54), arranged to be connected through the sixth contact (22) of the sunflower to a battery (55), and thence to ground at (56). The contacts of the secondary selecting relays are connected in tandem as follows: Relay (42) has two contact points connected by conductors (58) and (59), respectively, to movable contacts on the armatures of relay (43). Each of the movable contacts of relay (43) coacts with two contact points, each connected to a contact point on the armature of relay (44). In like manner the fixed contact points of relay (44) are connected each to an armature contact point of one of the two relays (45), and so on. The fixed contact points of relays (46) are connected to magnets (60), termed "printing magnets."

It will be seen that by means of the various secondary selecting relays (42) to (46) any one of the various magnets (60) may be selected at will for the completion therethrough of an energizing circuit. This is the circuit of conductor (54) and is completed, and the particular magnet selected is energized upon the closing of the sixth sunflower contact (22).

The carriage carrying the platen or printing roller of the machine may be of any suitable construction, and may be arranged to be returned to its starting point at will by any suitable means, such as a spring or motor. One end of the platen is illustrated diagrammatically in the drawing, being designated by number (68). The return of the carriage is governed by an electrically operated detent mechanism, of which (61) in the drawing designates the magnet and (62) the armature lever.

For spacing is employed a message comprising six dots, which message therefore does not cause the operation of any of the selecting relays, although it does cause the operation of the sunflower. Circuit is completed upon the closing of the sixth sunflower contact (22) through a back contact of one of each of the five series of secondary selecting relays and a circuit (69) to a spacing magnet (70), which may operate suitable spacing mechanism, such as is used on electrical typewriters.

The shift mechanism may be either a carriage shift or type shift, as preferred. In the drawing is indicated diagrammatically a type shift. This shift mechanism (73) comprises a magnet (74), arranged to be energized upon the transmission of a suitable corresponding selective signal, and when energized to attract its armature (75), thereby operating the shift mechanism.

The paper-feed employs a magnet (80) in one of the circuits controlled by the selecting relays, which circuit, like the circuit of the magnet (60), will be completed when the corresponding message is transmitted.

Economical Pulverization of the Thomas Slag.—A new process introduced by Herr Müller is described by Stahl und Eisen, in which the breaking and grinding of the slag are dispensed with. The slag is introduced into an old steam boiler, and subjected to the action of steam under high pressure. In a few hours the lime of the slag is spent, and the slag falls into a fine powder. By a special arrangement the pulverized product is obtained perfectly dry. The percentage of soluble phosphoric acid is from two to two and a half per cent higher than in the usual broken and pulverized product, resulting from the dissolution of a large part of the phosphoric acid by the new process. Tested in practice, the process has given better results than were expected.

* Western Electrician.

INTERRUPTERS FOR INDUCTION COILS.*

IT has been thought that an account of the more important forms of interrupter would not be unwelcome to readers of Nature.

A rotating air-break interrupter is shown in Fig. 1. An accurately balanced brass fly-wheel, *F W*, driven by a small motor, is fitted with two insulating segments, *I S*, let into its periphery. Bearing on the fly-wheel are two copper gauze brushes, B_1 and B_2; the circuit is interrupted as each brush slips over from the brass to

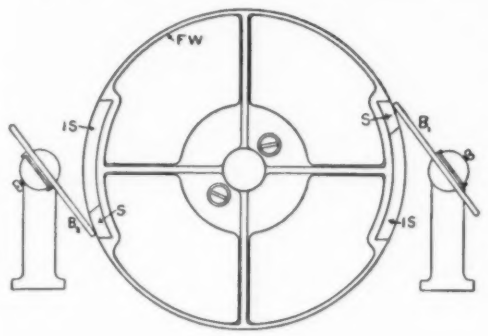


FIG. 1.

the insulating portion of the rim. It is evident that the arcing which occurs at the break necessitates the use of a fire-proof insulator. A small piece of slate (*S* in Fig. 1) is fitted immediately behind each brass segment, and this takes the spark; it is easily renewed, the remainder of each insulating segment consisting of vulcanized fiber.

So far as the writer is aware, this type of interrupter was first described by Wadsworth in 1894, and was used by Prof. Michelson in some Geissler-tube experiments (American Journal of Science, pp. 496-501, December, 1894).

As might be expected, the suddenness of the break depends on the speed of the motor (or frequency of interruption). In Fig. 2 are plotted the results of some experiments bearing on this point. It will be seen that for a given value (root-mean-square) of the primary current, an enormously greater spark-length—especially with the larger currents—is obtained at the higher speed.

This form of interrupter is not very expensive, and works very satisfactorily so long as the primary current does not exceed about 5 amperes. It shares with the platinum interrupter the advantage of cleanliness. Renewals and repairs cost very little, as the only parts which are subjected to any considerable wear are the slate distance-pieces; the rim of the fly-wheel may occasionally require truing-up. It is important to keep the edges of the brass contact-segments and the surfaces of the slate distance-pieces clean by the occasional application of fine sand-paper.

In Fig. 3 are shown the essential parts of the mechanism of a "double-dipper" interrupter. The double motor-driven crank, *C*, carries two connecting-rods, *C R*, each of which is attached to a cross-head, *C H*. Each cross-head is fixed to the top of a stiff rod, *R*, which passes between the guide-springs, *G S*, and through the guide-block, *G B*. The latter is supported by a strong bracket, *B*, screwed to the stand supporting the motor. Each reciprocating rod ends in an amalgamated copper wire, *C W*, which dips into the mercury. It will be readily seen that by the adoption of the two-crank arrangement the frequency is doubled for a given speed as compared with the single-crank interrupter; for while with the latter there is only a single break per revolution, the former gives two breaks per revolution, one of the contact-rods or "dippers" entering the mercury shortly after the other has

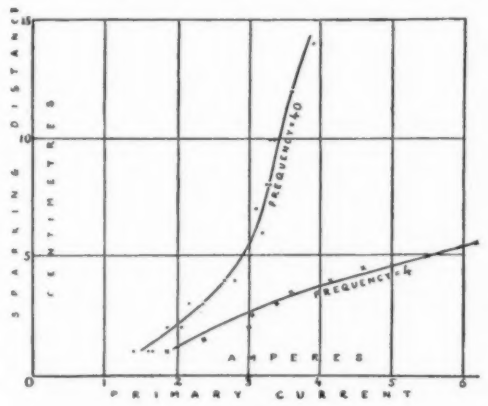


FIG. 2.

left it. The mercury cup itself is made adjustable in a vertical direction, and is, as usual, immersed in alcohol.

The curve marked "double dipper" in Fig. 4 gives the results of a test with this form of interrupter. The frequency of interruption was 22. The results correspond fairly well with those plotted in Fig. 2 for the rotary air-brake interrupter at a frequency of 40.

This type of interrupter is comparatively cheap and simple, and works very steadily. There is no complicated mechanism to get out of order, and only a small quantity of mercury is required (about two pounds).

One of the most successful types of rotary interrupter is the mercury jet interrupter. Several varieties of this have been used. One of the best known is shown in Fig. 5. The vertical motor-driven shaft, *S*, carries a cylinder, *C*, the lower portion of which is cut up into a number of teeth, *T*. The shaft *S* is continued downward, and passes through the mercury pump casing. The mercury pump is of very simple construction, and is shown in Fig. 5 (*b*). Inside a flat oval box, which forms the pump casing, are arranged two thick toothed wheels. One of these is mounted on the lower end of the shaft *S*, which carries the toothed cylinder, Fig. 5 (*a*), and drives the other. The wheels fit the inside of the casing very closely, and are arranged to rotate as indicated by the arrows in Fig. 5 (*b*). The mercury imprisoned between the teeth of the wheels and the casing is consequently carried round and forced through the nozzle. The issuing fine jet of mercury, *M J*—Fig. 5(*a*)—is directed against the rotating teeth, the break taking place at the vertical edge of a tooth. The height of the nozzle *N* is adjustable, and by this means the magnitude of the current may be regulated, as by raising the nozzle the jet will be directed against a tooth for a longer period, and the current will attain a larger value before the break takes place. The entire mechanism of this interrupter is contained in a strong cylindrical glass vessel, the lower portion of which contains mercury, in which the pump is immersed, and with which the pump chamber freely communicates by means of a suction orifice, while above the mercury is the usual alcohol filling the bulk of the vessel.

If in good working order, the mercury jet interrupter gives excellent results, as may be seen by referring to

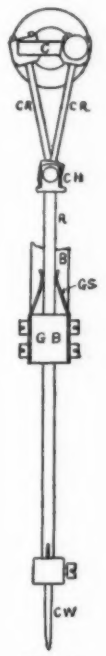


FIG. 3

the curve marked "mercury jet" in Fig. 4, which corresponds to a frequency of interruption = 40. A comparison of this curve with that given in Fig. 2 for the rotating air-brake interrupter at once shows the superiority of the jet interrupter. The mercury jet interrupter is much more expensive and complicated than the "double-dipper" type, and requires a larger amount of mercury; but it yields somewhat better results.

In Fig. 6 is shown the Wehnelt interrupter. A large rectangular glass vessel containing dilute sulphuric acid is fitted with an ebonite cover, *E C*, which supports the electrodes. The terminal, T_2, is in connection with the lead plate, *L P*, which forms the kathode. The bridge-piece, *B*, supports two rack rods, *R*, and the anode terminal T_1. Each rack rod is geared with a pinion by means of which it may be raised or lowered as required, *M H* being the milled heads for turning the pinions. The rack rods are continued downward in the form of thinner rods encircled by glass tubes, *G T*, and finally end in stiff platinum points, *P P*, around which the tapered ends of the tubes fit very closely. By raising or lowering either anode, a smaller or greater surface of it may be exposed to the surrounding electrolyte. The density of the acid depends on the voltage at which the interrupter is to be supplied. The interrupter is connected in series with the primary of the induction coil, and, if necessary, with an additional self-inductance. As soon as the circuit is closed, and provided the area of anode surface exposed to the electrolyte is not excessive, and the self-inductance not too small, the interrupter begins to act. A pink glow appears around the extremities of the anodes, the interrupter emits a loud note of definite pitch, and a shower of sparks is produced across the space between the secondary terminals of the coil. Bubbles of gas rush up each glass tube, *G T*, the electrolyte rises in each tube, and may overflow through the side openings, *O*.

Another form of electrolytic interrupter, originally due to Caldwell, but subsequently improved and modified in various ways by others, is shown in Fig. 7. The terminal T_2 is, as in the Wehnelt interrupter, connected to a lead plate. But instead of a platinum anode, a lead plate is also used for the other electrode. This second lead plate is surrounded by a glass tube, *G T*, which completely separates it from the remainder of the electrolyte except for a small perforation at the bottom of the tube, through which passes the pointed end, *P*, of a long glass rod, *G*, supported in a tubular rack rod, *R*, which may be raised or lowered by means of a pinion fitted with the milled head, *M H*. The area of communication between the electrolyte in the tube and that outside is controlled by raising or lowering the conical glass plug. Either electrode may be used

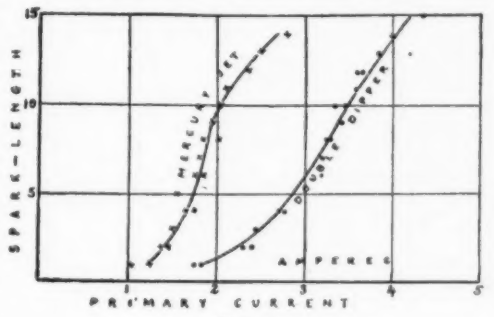


FIG. 4.

indifferently as anode or kathode. The break takes place at the perforation of the glass tube.

In conclusion, thanks must be expressed to Mr. A. C. Cossor, of 54 Farringdon Road, E.C., who very kindly provided an induction coil and a number of interrupters required to carry out the tests recorded in this article.

[Concluded from SUPPLEMENT No. 1533, page 24567.]

THE PRESENT STATUS OF ELECTRIC FURNACE WORKING.*

By CHARLES F. BURGESS, University of Wisconsin.

FURNACE CONSTRUCTION.

THE following are the essential features which must be considered in electric furnace design and construction:

Walls, containers, and crucibles, of refractory ma-

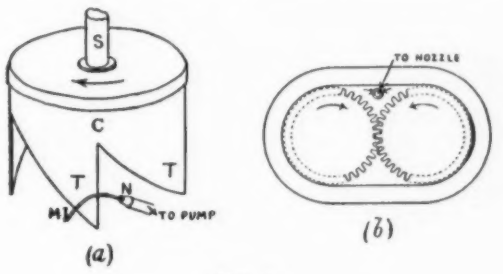


FIG. 5.

terials capable of resisting fusion, and the action of solid, liquid, and gaseous materials at the working temperatures.

Resistance medium, which may be solid, liquid, or gaseous.

Charge, which may be solid, liquid, or gaseous.

Electrodes, for conveying current to the resistance material.

Electrode terminals.

Provisions for feeding and emptying the furnace.

Outlets for escape of gaseous products, slags, etc.

Electrical regulating devices.

The refractory materials which are available for furnace construction are silica, magnesia, lime, chromite, alumina, carbon, graphite, siloxicon, and some other materials of minor importance. The choice of materials is governed by the temperature and the nature of the charge (whether acid or basic). For an acid lining silica is most satisfactory. This material in its

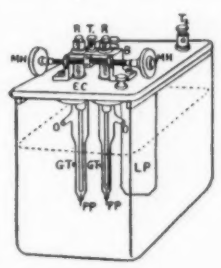


FIG. 6.

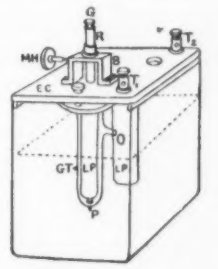


FIG. 7.

highest degree of purity resists a temperature of nearly 2,000 deg. C. It can be obtained in the form of bricks with a sufficiently low percentage of lime or other binding material to lower its melting point only a small amount. Such bricks are rather fragile, but there is a promising possibility that bricks made of pure fused quartz may soon be available. Lime and magnesium oxide are the materials most successfully employed by Moissan for the linings of his laboratory furnaces, and

* Nature.

* Presented before the Electrical Section February 10, 1905. Journal of Western Society of Engineers.

for industrial working a durable basic lining may be made of a high grade magnesite brick. Chromite and bauxite bricks are also valuable constructive materials. The most refractory substance which can be used is graphite, which can be obtained in a high degree of purity in any desired form, this being manufactured by molding and baking carbon and subsequently subjecting it to the graphitization process. The limitations upon this material are that it must be protected from the air or other oxidizing agents to prevent its combustion, and being a good electrical conductor, the furnace must be constructed so as to avoid short-circuiting by the carbon lining.

While electrometallurgists have been casting about for suitable refractory materials, they have usefully applied the electric furnace in the production of such materials. Carborundum is a refractory material, being suitable for certain purposes, and a newly discovered compound, designated "siloxicon," has been shown to have admirable qualities as a refractory material. It consists of a combination of carbon, silicon, and oxygen and is described as being very refractory to heat, insoluble in molten iron, indifferent to all acids save hydrofluoric, and self-binding to such degree that no binder is necessary in forming crucibles, furnace-linings and fire-bricks from it. FitzGerald also calls attention to other refractory materials which can be formed in the electric furnace. (See Electrochemical Industry, December, 1904.)

The resistance medium or "resistor," when solid, usually consists of a core of carbon, coke, or graphite, the technical features governing the use of which are ably discussed by FitzGerald. Metals may also be used, as in the well known platinum resistance furnace. Many other substances are available especially when we include those compounds which at ordinary temperatures are insulators, but which become conductors upon heating. Where such materials are used provisions are necessary for starting, somewhat similar to that used for starting the Nernst lamp, which, indeed, is a miniature electric furnace whose principles of construction may well be applied to furnaces of larger size.

Examples of liquid resistance materials are the aluminium furnace, and certain types of electric furnaces which have been applied for the melting of iron, steel, and other metals. Gaseous resistance mediums are utilized in the various arc furnaces and in the processes used for the production of nitric acid from the air.

The electrode problem is one that presents difficulties to the furnace designer. Baked carbon and graphite are by far the most important electrode materials. An ideal electrode material should possess high electrical conductivity, have little deterioration, not react chemically with the heated material with which it makes contact or introduce impurities into the charge. Carbon and graphite while fulfilling these requirements better than any other available materials are still very deficient as shown by the fact that electrode consumption constitutes a large proportion of the cost of various industrial operations and, in fact, is the real barrier to the commercial success of various promising processes. The electrode which usually projects a certain distance outside the furnace will burn away unless protected from the air. Various methods have been adopted for doing this, such as incasing in a thin iron covering, or keeping it cool by a continual stream of water. In some of our experiments at the University of Wisconsin it has been found that certain fused substances could be formed on the surface making a layer of glass completely excluding the air, and protective even at a white heat.

Iron and certain other metals may in some cases be used as electrodes where carbon is prohibited, and to insure their durability they are kept cool by a continual stream of water. This protection is afforded by a decrease of efficiency, due to the carrying away of considerable quantities of heat.

Another problem, which is by no means insignificant, is the matter of electrode connection. It is difficult to insure good conductivity between a metal in contact with carbon or graphite, and poor contact results in excessive development of heat at that locality. The brittle and fragile nature of the electrode materials precludes tight clamping. One of the leading electrometallurgical companies using graphite electrodes in a process in which that material suffers little or no corrosion, nevertheless was a large consumer of graphite, as the unequal expansion of that material and the metal terminals to which contact was made caused much breakage.

An ingenious form of furnace which avoids electrode difficulties by eliminating the electrodes altogether has been developed. This is accomplished by causing the resistance material to constitute the secondary of a transformer. This induction type of furnace can be used only to heat materials having a good conductivity such as a melted metal, since it is not possible to set up a high pressure in the secondary of a transformer, when the secondary consists of a single turn. A furnace of this type is reported to be in successful use for the melting of iron and the production of steels. While it is true that electrode difficulties are thus eliminated, additional complications arise as the heating trough must be long and narrow, conducing to excessive radiation and low efficiency; the core of the transformer and the primary windings must be kept cool, to do which still further lowers the percentage of useful heat; and the construction of the transformer is necessarily such as to give it a low efficiency and low power factor.

The provisions for feeding and emptying the furnace have much to do with its successful operation, and many laboratory processes fail commercially on this ground. The laboratory furnace is necessarily an intermittent one, as it is usually necessary to cool down and take the furnace apart to recover the charge. To a certain extent the intermittent furnace has been successful industrially, the carborundum furnace being an example. Calcium carbide was made exclusively by the intermittent process until commercial conditions demanded continuous operation and a complete reconstruction of the forms of furnaces to attain it. The ultimate success of the industrial application of the electrical furnace demands that it be so constructed that material can be fed to it continually and the finished material likewise extracted, for its efficiency is thus greatly enhanced, the load on the generators is maintained constant, uniformity of product is insured, and equipment can be used with greatest efficiency. Continuous operation also calls for the escape of gaseous products, or any slags or other by-products which are formed.

It was previously pointed out that the degree of temperature, control of speed of operation, and speed of gradation from one temperature to another are subject to the will of the operator. This is true, however, only when he has suitable regulating devices and apparatus, the design and construction of which lie wholly within the province of the electrical engineer. Where the furnace furnishes an absolutely constant load the problem becomes simple, but is almost too ideal to be considered. Even where operation is continuous, any change in the rate of feeding or the withdrawing of the material, inequality of the material, outside temperature, etc., introduce variations, allowance for which must be made by the operator. For constant-current working, regulating devices similar in principle to those of the arc lamp may be provided, and in fact some of the furnace patents have simply been arc lamp patents slightly modified. The regulation must be effected in such manner that short-circuiting or sudden change in the resistance in the furnace shall not harm the generating system, or interfere with the operation of other furnaces receiving power from the same generators. In intermittent working, the regulating apparatus must permit adjustment from no load to full load, either gradual or rapid as the case may demand. The alternating current has naturally lent itself more satisfactorily than the direct and consequently is used almost exclusively. Multiphase currents are in many cases superior to the single phase on account of the more even distribution of heat, and the use of such currents introduces additional electrical problems.

COMPARATIVE EFFICIENCY OF THE ELECTRIC FURNACE.

It has been pointed out that the electric furnace has won an industrial position, not as a competitor of the combustion furnace, but rather in the field of high temperature working where the latter cannot enter. To a small extent, however, it has become a rival to fuel furnaces owing to certain advantages it possesses, such as safety to workmen and purity of product. As an example of this, take the manufacture of carbon bisulphide and phosphorus, most of which is now produced electrically. Only a few years ago it was generally predicted that there was little possibility of the electric furnace being so developed as to compete with ordinary metallurgical furnaces in the production and treatment of metals such as iron, steel, copper, lead, and zinc. While it was admitted that perhaps the electric furnace might insure lower labor and depreciation charges, less waste of material, higher quality of product and other advantages, it was stated that the cost of electric energy was so much greater than an equivalent amount of heat energy, derived directly from combustion, that no possibility of equal economy could exist. Calculation, as well as recent developments, shows this view to be erroneous.

Assuming that coal at $2.50 per ton has a calorific value of 14,000 B. T. U., the quantity of heat energy obtainable for one dollar is 11,200,000 B. T. U. One electrical horse-power-year has for its heat equivalent 22,400,000 heat units. If electrical horse-power-year generated by means of steam be assigned a value of $50, one dollar will produce about 450,000 B. T. U. Assuming equal efficiency in the utilization of the heat derived from the two sources the ratio of the cost of energy is as one to twenty-five. This discrepancy shows the handicap which steam-generated electricity has for electric furnace operation. The development of enormous water power has resulted in great reduction in the cost of generating electrical energy in certain localities. There has been much discussion of late as to how cheaply hydraulically generated electrical power can be produced. In the report of the commission appointed by the Canadian government to investigate electrometallurgical processes a value of $10 per horse-power-year was given as a reasonable estimate. At this figure, the heat units per dollar become 2,250,000, which is about one-fifth that obtainable from one dollar's worth of coal.

The question of efficiency of heat utilization comes in to even up matters still more. It is a well-known fact that the efficiency of the combustion furnace is less than 100 per cent by an amount dependent upon the heat which is radiated or conducted away from the furnace, that which goes up the chimney with the products of combustion, and various other minor losses. The percentage loss increases with elevation of temperature, and at a rapidly increasing ratio as the temperature rises.

The efficiency of the ordinary furnace for steam generation is not far from 60 per cent, this high value being attained by the low temperature, about 250 deg. C., to which the steam is heated. The metallurgical furnace having the highest efficiency is the blast furnace for the production of pig iron, which has a thermal efficiency of from 50 to 80 per cent. This exceptional economy is due to the fact that the fuel is in direct contact with the material to be heated, producing a direct transference of heat. However, for this purpose, the cheaper grades of fuel cannot be used, a hard pure coke or charcoal being required at a cost several times greater than that for the cheaper kinds of fuel.

In the reverberatory furnace, in which the products of combustion pass directly over the charge to be heated, the efficiency is much lower, and a still lower value is obtained in those furnaces in which the heat must pass through refractory walls. In such crucible, muffle, and retort furnaces the efficiency varies from 2 to 10 per cent.

Table I. gives results of efficiency calculations on several types of furnaces, as compiled from various authorities:

TABLE I.

Product.	Type.	Thermal efficiency.
Steam		50-60 p. c
Cast iron	Blast	52-66 p. c.
Steel	Acid process	11.9
Steel	Basic process	10.0
Pig iron	Reverberatory	8.5
Wrought iron	Reverberatory	5
Steel	Siemens crucible	4
Steel	Greenwood crucible	2
Zinc	Retort	2 to 3

The values of efficiency given for steel and wrought iron are based upon comparisons of the heat theoretically required to raise the metal to the molten state, with that furnished by the amounts of coal used in the practical operation of the various processes and assuming a calorific value for the fuel of 14,000 B. T. U.

Capt. Stassano (Report of Canadian Commission, p. 180) says that "the utilization of the potential heat of the fuel in the ordinary furnaces is maintained to a very limited and low degree, varying, in fact, from 2 per cent to 3 per cent and even less, in the ordinary fires of a forge, rising to 10 per cent in the common reverberatory furnace, and reaching the maximum of 18 per cent to 20 per cent in those modern gas furnaces with regenerators (Martin-Siemens' type)."

ELECTRIC FURNACE EFFICIENCY.

The simplest and most easily effected of the energy transformations with which we have to deal is the change of electrical into heat energy, such transformation being easily effected at an efficiency of 100 per cent. This cannot, however, be taken as the value for electric furnace efficiency, for we can consider only that heat which is usefully applied. The heat usefully applied may be that required for melting or volatilizing a substance, or for producing other desired physical or chemical changes in it, and it is this amount of heat as compared with the total heat equivalent delivered to the furnace that determines its efficiency. Prof. Joseph Richards (Trans. Am. Elec. Chem. Soc., vol. 2, 1902) discusses electric furnace efficiencies at length, and from his calculations Table II. is compiled:

TABLE II.

Type	Product	H. P.	Temperature	Efficiency
Acheson	Graphite	1,000	3300 deg. C.	75 per cent.
Jacobs	Fused Al_2O_3	200		74 " "
Acheson	Carborundum	1,000	3000 deg.	76.5 " "

The conclusion is drawn that a commercial efficiency of 75 per cent is readily obtainable in electric furnaces ranging in size from 200 to 1,000 horse-power, and this value can undoubtedly be raised by increasing the size and bettering the construction as regards heat insulation.

The estimates of efficiency at high temperatures can be only approximations, for ignorance regarding specific heats of material at such temperatures is a bar to exact calculations.

From previous calculations it can be seen that the industrial electric furnace operates at an efficiency over five times as great as that of the industrial combustion furnace, and consequently electrical energy at $10 per year can compete on an even basis with coal at $2.50 per ton.

The electric furnace efficiencies, as calculated by Richards, are obtainable while working at temperatures of 3,000 deg. and above, which is far in excess of that attainable in combustion furnaces. A comparison even more favorable to electrical heating may be obtained where the electric furnace is applied to lower temperature working, such as in the metallurgical treatment of iron and steel. Sir William Siemens found an efficiency of 50 per cent in utilizing 2 horse-power for melting iron, and with such efficiency attainable in a small laboratory furnace, the larger industrial furnaces ought to be nearer 100 per cent than 50 per cent. Capt. Stassano, from calculation and experience, says that the electrical steel and iron furnace can be safely assumed to have an efficiency of 80 per cent.

Of such great promise is the use of electrical energy in the metallurgy of iron and steel that the Canadian government appointed a commission to thoroughly investigate the state of the art. The report, which has recently been distributed, is a most important addition to our electrometallurgical literature and will undoubtedly do much toward establishing confidence in electric furnace methods. Table III. gives extracts from this report, the figures being obtained by tests which the

ommission made upon various processes in operation in Europe:

TABLE III.

Process	Product	Mean H. P.	H. P. year per ton of product	Power factor	Frequency
Heroult	Pig Iron	248	0.47	75 (about)	80
Keller	Pig Iron	834	0.475	73.7	50
Keller	Pig Iron	308	0.229	56.4	37
Kjellin	Steel	195	0.116	67.2	15
Kjellin	Steel	203	0.145	64.9	15
Heroult	Soft Steel	480	0.153		33
Heroult	Tool Steel	462	0.158		33
Heroult	Structural Stee.	485	0.10		33
Keller	Steel	240	0.112	85 (about)	40

"Coke used in crucible melting in Sheffield to-day probably varies from 2 to 3½ tons per ton of steel produced, and even in the large gas-fired furnaces employed in America and Germany probably one ton of slack, costing not less than $2.50, is necessary."

The 0.15 horse-power-year necessary to produce one ton of steel by the electrical processes has for its heat equivalent 3,360,000 B. T. U, and one ton of coal at 14,000 B. T. U. per pound has a value of 28,000,000 units. If the gas firing process be assumed to have 10 per cent efficiency, the efficiency of the electrical process figures out about 80 per cent, thus confirming previous estimates.

To quote from the "Conclusions" of the Report, we have the following significant statements:

1. "Steel, equal in all respects to the best Sheffield crucible steel, can be produced by the Kjellin, or Heroult, or Keller process at a cost considerably less than the cost of producing a high class crucible steel."

8. "Pig iron can be produced on a commercial scale at a price to compete with the blast furnace only when electrical energy is very cheap and fuel very dear. On the basis taken in this report, with electrical energy at $10 per E. H. P. year, and coke at $7.00 per ton, the cost of production is approximately the same as cost of producing pig iron in the modern blast furnace."

The report of the Canadian Commission demonstrates the possibility of employing electric heating for low temperature furnace working by showing that it has an opportunity in the metallurgy of iron and steel. This was deemed only a most remote possibility a few years ago. Now if the metallurgy of iron can find a place for the electric furnace, how much greater opportunity there is for it in the successful treatment of some of the other metals. The present methods of extracting zinc are notoriously inefficient. Not only is the 80 per cent efficiency of the electric furnace as compared with the 3 or 4 per cent efficiency of the ordinary zinc furnaces capable of resulting in an economy, but various other advantages may be attained as well. The cost of zinc production under present conditions involves incomplete extraction from the ore, absorption of zinc by the walls of the retorts, rapid destruction of retorts, and losses in the condensation of zinc. Electric furnace methods present opportunities for materially remedying these defects. In laboratory trials made at the University of Wisconsin it has been found possible to completely extract the zinc, so that none of it remains in the charge or is retained in the walls of the furnace. No practical form of furnace for this purpose has been evolved, however, the principal difficulty being in effecting continuous operation, a requirement which is almost imperative.

It is of importance that our metallurgists should continue their researches in the practical application of the electric furnace to the smelting of copper and other ores, not only those which are now successfully treated by other methods, but more especially that large class of ores which has proved refractory to all economical processes so far as known.

Various miscellaneous applications of minor importance might be cited. The electric welder is essentially an electrical furnace which has been most successful industrially. We have been working in our laboratory on an electric furnace for the tempering of high melting tool steel with considerable success, the process consisting in maintaining a fused bath at a high temperature and immersing the steel to be treated in it.

The electric furnace seems to point the way to a limitless outlet for all the electrical energy which can be developed. The pessimist who points to the calcium carbide industry to support his claim that the electric furnace has been over-developed takes an extremely narrow view. It is true that the enthusiasm with which investors went into the carbide industry resulted in overproduction and a consequent failure of some of the plants, but instead of being a setback for the electric furnace it has been an advantage. The strenuous efforts to find uses for the furnace equipment in other directions has resulted in a successful production of iron and its various alloys. Recent experimental work seems to indicate that calcium carbide will work out its own salvation. It has been discovered that if calcium carbide be heated in the presence of nitrogen, which may be obtained from the air, a calcium cyanamide is formed which, when treated with steam, forms ammonia, and when treated with water and fused with sodium carbonate gives sodium cyanide and ammonia. In other words, it constitutes a process for fixing the nitrogen of the air.

In this connection may be noted a new and interesting apparatus which might properly be classed as an electric furnace and which is used for making nitrogen compounds from the air by means of electrical discharges. A paper presented at the meeting of the International Electrical Congress a few months ago in St. Louis, giving the results of tests on a new method by Prof. C. Birkeland and Mr. Eyde of Christiania, shows that it is possible to produce 1,490 pounds of nitric acid per horse-power year, from which can be made calcium nitrate and other nitrates of unlimited usefulness to agricultural interests. The world is facing the possible calamity of an exhaustion of the nitrate beds of Chili, which according to estimates cannot continue to supply the demand for sodium nitrate for more than forty or fifty years. This sodium nitrate, selling at 2 cents per pound, and used chiefly as a fertilizer, has its chief value in its content of nitrogen, and the cost of nitrogen per pound from this source is about 12 cents. According to Prof. Birkeland's statement one pound of nitrogen in the form of nitric acid can be produced electrically for an expenditure of power of about 3 cents. The energy consumption is not, therefore, an effectual barrier to the economic production of nitrogen compounds from materials which are most abundant and inexhaustible, and a process worked out along such lines will probably be ready for adoption on a large scale before nature's store of valuable nitrates becomes exhausted.

ELECTRICAL NOTES.

The United States Circuit Court of Appeals has rendered a decision in the suit brought by the Westinghouse Electric and Manufacturing Company for a preliminary injunction against the Montgomery Light and Power Company for alleged infringement of the Stanley transformer patent, reversing the decision rendered by the lower court. The court states that the lower court "held that the defendant's system of electrical distribution infringed the first and third claims of the Stanley patent, whether the length of the primary coil of its transformer had been ascertained by applying the Stanley rule or by some method of which Stanley was not the discoverer," and adds: "To this extent we agree with the court below." It further holds that its own decision in the suit of the Westinghouse Company against the Saranac Lake Company "was in effect that Stanley contributed to the prior art the discovery that the automatic and constant regulation of the pressure of the alternating current at the secondary terminals depended upon the co-ordination of the transformer to the generator, and the invention that this could be effected by means of a primary wire of suitable length; that the first and third claims of the patent were for combinations which broadly included his invention." The Court of Appeals, however, holds that in the present motion for preliminary injunction, the depositions deal "with an abstruse and recondite subject, and present conflicting theories which cannot safely be accepted without the searching elucidation which a cross-examination of the experts may afford." In view of the large importance of the controversy, the court concludes that the rights of the parties should be reserved for decision until the final hearing of the cause.

The singular behavior of selenium in regard to electric currents has been known for a number of years. It will be remembered that the conductivity of this element increases rapidly when it is illuminated. When inserting in a circuit a so-called selenium cell, the current can be increased by illumination from a great distance to such an extent as to exert a given mechanical effect. This has been utilized in the photophone invented by Bell and improved by Ruhmer, where sound, light and electric currents are brought in connection with much ingenuity. Another application of selenium, viz., for comparing clocks and recording pendulum oscillations from great distances, is due to a Heidelberg astronomer, Mr. Courvoisier, who according to our contemporary Die Elektrizitaet, No. 12, has found in selenium a means of obviating such drawbacks as are inherent in the old method, where the pendulum itself makes contact and thus completes the current; in these experiments he was assisted by Dr. Kalähne, a physicist of Heidelberg University. With any device designed after the old method, a reaction of the contact-making devices on the working of the clock was quite unavoidable. Though this reaction be small, it would still make itself felt in astronomical clocks, where hundredths and thousandths of a second have to be taken into account. The principle of the new method is as follows: To the pendulum is connected a mirror, the plane of which is parallel to that of the pendulum. An illuminant is so arranged that the pendulum just on its passage through the lowermost point, that is to say, when its motion is most rapid, reflects the rays for a moment on a distant selenium cell, which is inserted in the circuit of a weak current. The luminous effect is enforced by a convex lens arranged in front of the cell. In connection with the experiments made at Heidelberg, the cells had a resistance of 70,000 ohms in the dark, which, however, was lowered to 1,500 ohms under the action of the rays from a 16-candle incandescent lamp, placed in the neighborhood. A petroleum lamp could, however, be substituted for the electric lamp. A sensitive relay would transmit the current closure to the stronger current of a chronograph, recording the vibrations of the pendulum on a strip of paper. Measurements made on the latter gave very satisfactory results as to the accuracy obtained, the more so after the selenium cell had become accustomed to the periodical process, and had assumed a certain permanent condition. As the chronographical records are made by the clock only for some minutes each time, the small heating of the pendulum due to the illuminant will hardly exert any influence, especially in case protective screens are used.

ENGINEERING NOTES.

An electric trolley system has been put into service in Hongkong, China. The principal object of this road is to afford transportation facilities to the European residents of Hongkong. It is said, however, that the native Chinese are now using the road a good deal, although they first viewed it with suspicion, believing it to be a contrivance of the devil. Until this road was started the principal means of transportation in Hongkong was the rickshaw, drawn by Chinese coolies.—International Railway Journal.

Improvements at the port of Trieste have been materially extended at various dates during the past two centuries, but the constructions now in progress will add greatly to former facilities. The Zeitschrift des Oesterreichischen Ingenieur-Vereins describes them and states that the quays of the new port of St. André will aggregate 4,800 meters in length; the new basins will occupy 39 hectares, the sheds 13 hectares, and the warehouses 18 hectares. The entire port will have 13 kilometers of quays and 106 hectares of basins.

There is considerable lack of agreement as to what is implied by the term "boiler." One ought not to recognize the brick walls which inclose it, the cast-iron fire bars, the stoker machine or the furnace as being in any way a part of the boiler. Manufacturers take orders for, and contract to deliver under penalty, what they designate as a "boiler," and they deliver and receive payment for a metal structure, tight enough not to leak, and strong enough to withstand pressure, but no fire bars, stoker, furnace or brick walls are included in the delivery. These features are often supplied by others who are not in the boiler business. Thus a boiler must have an individuality.

Work on further track elevation, costing $3,075,000, was done by the railroads of Chicago in 1904, according to the annual figures submitted by the track elevation superintendent, Mr. John O'Neill. The elevation of the entire yard of the Pittsburg, Fort Wayne and Chicago, between Forty-seventh Street and Garfield Boulevard, practically has been finished. Another season will end the work. Retaining walls from Twenty-third to Fifty-fifth Street, and abutment foundations have been put in, all at a cost of $1,000,000. The Pittsburg, Cincinnati, Chicago and St. Louis Road has completed practically the work of elevating the Englewood connecting branch to Halsted Street, costing $200,000. The Burlington Road spent $325,000 on retaining walls along Sixteenth Street. The Chicago and Northwestern Road spent $500,000 for retaining walls in Kinzie Street, and similar work. The Union Stockyards and Transit Company has completed the subway in Forty-seventh Street, between Morgan and Halsted streets, costing $200,000. The Chicago and Western Indiana Road, between Forty-seventh and Fifty-first streets, has spent $500,000 on fillings, retaining walls, power houses, and other work. Ordinances were introduced in the council November 21 providing for track elevation work to cost $4,610,000. Mr. O'Neill shows what has been done and what remains in a series of summaries, as follows: Miles of main track elevated, 82.84; miles of all tracks elevated, 425.19; subways constructed, 360; estimated cost of work done, $29,725,250. This leaves work to be done, under ordinances passed between 1892 and 1905, as follows: Miles of main track to be elevated, 55.26; miles of all tracks to be elevated, 284.76; subways to be constructed, 177; estimated cost, $14,475,000.—The Railway and Engineering Review.

The Belgian government have authorized a huge scheme for improving the port of Antwerp, the traffic of which during the past twenty years has so developed as to have outgrown all possible facilities for its improvement. Owing to the meandering nature of the river Scheldt between Lillo and Antwerp, it is feared that the channel of the waterway will become so choked between these two points as to render maritime traffic impossible. According to the present scheme, which was first propounded twelve years ago, an entirely new course for the Scheldt is to be cut, passing inland at Lillo, and curving gently in a quarter-circle, so as to join the natural bed in front of Antwerp at the point where the river turns abruptly in front of the city. This new course will be some six miles in length. There was one great objection to this project, however, and that was the danger of totally obstructing traffic during the progress of the works, a danger which it was feared would irretrievably divert navigation from Antwerp to the rival ports of Rotterdam and Dunkirk. In the latest scheme, however, all such apprehension has been removed, since a gigantic canal to run parallel with the proposed new bed is to be cut to serve as a temporary waterway while the new bed of the river is being excavated. This canal is to run from the river at Kruischanz—just above the river from Lillo. The entrance is to be effected through three sluices, 975 feet long and 97 feet wide, and deep enough to allow for the passage of the heaviest laden and largest ocean liners. Along one side of this canal there are to be nine open basins, 4,000 feet long and 800 feet wide, besides drydocks large enough for all liners and a semi-circular open basin, 1,650 feet in diameter. The new course for the Scheldt will not be commenced until the canal and its open basins are completed and accessible. The great dredging machines invented and used by Mr. Bates, who dredged the Mississippi, will be employed. A large island will be formed between the old bed of the river and the new, which will be used for industrial purposes. On this land there are three villages, which will be transported by the government. The project will take from ten to fifteen years to complete, and the cost is estimated at $50,000,000.

SCIENCE NOTES.

During the summer of 1904 over fifty reservoirs were successfully treated for the removal of algæ by the Department of Agriculture. From these results and from further experiments in the laboratory and elsewhere the following facts have been developed: Much less copper is required to eradicate algæ from reservoirs than would be necessary to destroy algæ under laboratory conditions. The effect of this metal upon fish is of considerable importance and requires more study. The physical and chemical constitution of a water are factors to be considered in determining the quantity of copper sulphate to use in a water supply. The elimination of polluting forms sometimes makes possible the development of other species, but so far these species have never been the cause of complaint. As a result of the sudden destruction of great numbers of polluting algæ for a few days immediately after treatment of a water supply there is sometimes an increase in odor and taste. The use of copper is an efficient emergency method for sterilizing water contaminated with the bacillus of typhoid fever. Metallic copper offers a convenient and efficient means of sterilizing small amounts of water. Copper may be useful in the proper disposal of sewage. Copper is of great value as a supplement to filtration in case of accident or mismanagement. Under certain conditions copper may be used to great advantage in connection with filtration. There is no authentic record of fatal copper poisoning, and many of the best authorities do not consider copper a true poison; they hold that it is a natural constituent of the body, and in minute quantities has no effect upon man. The suggested medicinal use of copper in cholera, typhoid, and related diseases seems important.

The toxicology of cerium and its compounds is the subject of a memoir recently presented by Dr. P. Hollande. He made different experiments as to the influence of cerium upon the lower vegetable orders such as *Aspergillus niger*, the pyocyanic bacillus, the *Bacillus subtilis* of Ehrenberg, as well as upon the lower forms of animal life, and upon different animals including the guinea-pig, rat, dog, and rabbit. These researches are especially difficult, as it is necessary to purify the cerium salts beforehand, seeing that the commercial products are generally impure. From a great number of observations which he made, Dr. Hollande was led to deduce some important physiological conclusions, among which we may mention the following. The salts of cerium are toxic, and the ceric salts are more so than the cerous. Whatever may be the method of absorbing the salts, we find at once a rapid lowering of the temperature and this may even be mortal. The cooling effect is especially noticed with the double salts of cerium. While the injection of a pure salt of cerium always gives a cooling effect, the injection of a lanthanum or didymium salt in the pure state causes a heating. The cerium salts are caustic in their action, coagulating the albumens, and are to be compared in this regard with chloride of antimony and chloride of zinc. The elimination of cerium is carried on rapidly. In the cases of chronic poisoning, it is found in the urine, the fecal matter, and the liver. As regards the symptoms which are produced, there are some striking analogies between cerium and lead, and in Rabuteau's classification it seems that cerium should be placed among the nervo-muscular poisons, along with lead. The best treatment in the case of absorption of cerium is by washing the stomach with a slightly basic water, so as to cause a precipitation of the salt as a hydrated oxide.

According to Dr. G. Johnstone Stoney in Monthly Weather Review, in the stratum of the earth's atmosphere from which helium escapes opportunities of exchanging energy between the internal motions and the translational, instead of occurring to each molecule several times per second, may be so infrequent that they occur only once in several hours. During all its intermediate flights the molecule is exposed during the daytime to the full glare of radiation as intense as direct radiation from the sun's photosphere. In this way the internal motions of the molecule will be kept for some hours excited to intense activity, and if during these hours that special kind of encounter happens to take place which affords an opportunity for an interchange between the internal and translational energies, the two encountering molecules will fling asunder with what may be described as explosive violence. All that is then necessary for a molecule to escape is that one of the two that have encountered shall have the direction of its flight outward, that it shall have sufficient speed, and that it shall escape other encounters. If the chance that these events shall happen befalls each molecule in the penultimate stratum of the helium atmosphere as often as once in several days, there would probably be an abundant outflow of helium from the earth to account for the observed rate of its escape. Here, however, we are on debatable ground. We can only follow events in detail with probability, not with certainty. But on the other hand, when we trust to the inductive argument based on the ascertained behavior of helium, we are on secure ground. We may rely on the conclusion to which it leads, viz., that helium is escaping from the earth's atmosphere, and that the rate of escape is the same as the rate of the net inflow from the earth into the atmosphere. By the net inflow is meant the supply after deducting something like 1/6000 or 1/3000 part of the whole, in order to allow for the very minute quantity of helium that had been washed out of the atmosphere by rain and which is being restored to it.

VALUABLE

Scientific Papers

ON TIMELY TOPICS

Price 10 Cents each, by mail

ELECTRONS AND THE ELECTRONIC THEORY are discussed by SIR OLIVER LODGE in SCIENTIFIC AMERICAN SUPPLEMENTS **1428, 1429, 1430, 1431, 1432, 1433, 1434.**

THE PANAMA CANAL is described from the engineering standpoint in SCIENTIFIC AMERICAN SUPPLEMENT **1359.**

WIRELESS TELEGRAPHY. Its Progress and Present Condition are well discussed in SCIENTIFIC AMERICAN SUPPLEMENTS **1425, 1426, 1427, 1386, 1388, 1389, 1383, 1381, 1327, 1328, 1329, 1431.**

HOW TO CONSTRUCT AN EFFICIENT WIRELESS TELEGRAPH APPARATUS AT SMALL COST is told in SCIENTIFIC AMERICAN SUPPLEMENT **1363.**

SUBMARINE NAVIGATION. An exhaustive review of the subject is published in SCIENTIFIC AMERICAN SUPPLEMENTS **1414, 1415, 1222, 1223.**

SELENIUM AND ITS REMARKABLE PROPERTIES are fully described in SCIENTIFIC AMERICAN SUPPLEMENT **1430.** The paper is illustrated by numerous engravings.

THE INTERNAL WORK OF THE WIND. By S. P. LANGLEY. A painstaking discussion by the leading authority on Aerodynamics, of a subject of value to all interested in airships. SCIENTIFIC AMERICAN SUPPLEMENTS **946** and **947.**

LANGLEY'S AERODROME. Fully described and illustrated in SCIENTIFIC AMERICAN SUPPLEMENTS **1404** and **1405.**

STEAM TURBINES. Their Construction, Operation and Commercial Application. SCIENTIFIC AMERICAN SUPPLEMENTS **1306, 1307, 1308 1422, 1400, 1447, 1370, 1372, 1521.** The articles have all been prepared by experts in steam engineering.

PORTLAND CEMENT MAKING is described in excellent articles contained in SCIENTIFIC AMERICAN SUPPLEMENTS **1433, 1465, 1466, 1510, 1511.**

AERIAL NAVIGATION. Theoretical and Practical Discussions. Pictures and Descriptions of actually-built dirigible balloons and aeroplanes will be found in SCIENTIFIC AMERICAN SUPPLEMENTS **1161, 1149, 1150, 1151, 1404, 1405, 1413, 1455.**

THE TANTALUM LAMP. A full illustrated description of a lamp having a metallic filament and burning at once without preliminary heating appears in SCIENTIFIC AMERICAN SUPPLEMENT **1523.**

THE WATERPROOFING OF FABRICS is thoroughly discussed in SCIENTIFIC AMERICAN SUPPLEMENT **1522** by an expert.

THE SPARK COIL, its construction and maintenance is the subject of a painstaking article in SCIENTIFIC AMERICAN SUPPLEMENT **1522.**

ELECTRIC IGNITERS FOR GAS ENGINES are discussed in SCIENTIFIC AMERICAN SUPPLEMENT **1514.**

CARBURETERS, a subject of immense importance to automobilists and users of oil engines, is well treated in SCIENTIFIC AMERICAN SUPPLEMENT **1508.**

EPICYCLIC TRAINS, which play an important part in toothed gearing, are ably described in SCIENTIFIC AMERICAN SUPPLEMENT **1524.**

Price 10 Cents each, by mail

MUNN & COMPANY

361 BROADWAY NEW YORK

Home Mechanics for Amateurs

This book has achieved an unparalleled success in one week, and a Special Edition of 4,000 copies has been ordered. It is by far the largest and best book on the subject ever offered at such a low price. It tells how to make things the right way—the "only" way—at small expense It will prove of value to you—much more than you realize. Do things with your hands. Send for a circular giving contents—the circulars cost only a cent—the book $1.50 postpaid. If the book could meet you face to face you would be the first to purchase. The first large edition is almost gone. Order to-day.

370 Pages 326 Engravings Price $1.50

THE SCIENTIFIC AMERICAN

CYCLOPEDIA OF RECEIPTS, NOTES and QUERIES

15,000 RECEIPTS 734 PAGES POST FREE
Price, $5.00 in Cloth $6.00 in Sheep $6.50 in Half Morocco

This work has been revised and enlarged

900 NEW FORMULAS

The work is so arranged as to be of use not only to the specialist, but to the general reader. It should have a place in every home and workshop. A circular containing full TABLE OF CONTENTS will be sent on application.

Those who already have the Cyclopedia may obtain the

1901 APPENDIX

Price, bound in cloth, $1.00 postpaid

MUNN & CO., Publishers, 361 Broadway, NEW YORK CITY

THE

Scientific American Supplement.

PUBLISHED WEEKLY.

Terms of Subscription, $5 a year.

Sent by mail, postage prepaid, to subscribers in any part of the United States or Canada. Six dollars a year, sent, prepaid, to any foreign country.

All the back numbers of THE SUPPLEMENT, from the commencement, January 1, 1876, can be had. Price, 10 cents each.

All the back volumes of THE SUPPLEMENT can likewise be supplied. Two volumes are issued yearly. Price of each volume, $2.50 stitched in paper, or $3.50 bound in stiff covers.

COMBINED RATES.—One copy of SCIENTIFIC AMERICAN and one copy of SCIENTIFIC AMERICAN SUPPLEMENT, one year, postpaid, $7.00.

A liberal discount to booksellers, news agents, and canvassers.

MUNN & CO., Publishers,
361 Broadway, New York, N. Y.

TABLE OF CONTENTS.

PAGE

I. CIVIL ENGINEERING.—Engineering Notes..... 24567
Reinforced Concrete..... 24574

II. ELECTRICITY.—Barclay's Printing Telegraph.—1 illustration.. 24584
Electrical Notes..... 24567
Interrupters for Induction Coils.—7 illustrations..... 24585
The Present Status of Electric Furnace Working.—By CHARLES F. BURGESS..... 24585

III. HYDRAULICS.—The Hydraulic Power Works on the River Glommen, Norway.—11.—5 illustrations..... 24574

IV. MECHANICAL ENGINEERING.—The Modern Gas Engine.... 24575
Rotary Engines..... 24582

V. MISCELLANEOUS.—An Artist's Prophecy.—5 illustrations..... 24580
Candles, Old and New..... 24585
Desert Plants as a Source of Drinking Water.—By FREDERICK V. COVILLE.—6 illustrations..... 24581
Limits of Sensibility of Odors and Emanations..... 24580
Science Notes..... 24588

VI. PHYSICS.—The Velocity of Propagation of X-rays.—1 illustration..... 24575
A Little-known Property of the Gyroscope..... 24579

VII. SANITATION.—Copper as an Algicide and Disinfectant in Water Supplies.—By KARL F. KELLERMAN..... 24578

VIII. TECHNOLOGY.—Lead Pencils We Use Every Day.—20 illustrations..... 24576
The Venetian Silkworm Industry..... 24583

PATENTS!

MUNN & CO., in connection with the publication of the SCIENTIFIC AMERICAN, continue to examine improvements, and to act as Solicitors of Patents for Inventors.

In this line of business they have had over *fifty years' experience*, and now have *unequaled facilities* for the preparation of Patent Drawings, Specifications, and the prosecution of Applications for Patents in the United States, Canada, and Foreign Countries. Messrs. MUNN & CO. also attend to the preparation of Caveats, Copyrights for Books, Trade Marks, Reissues, Assignments, and Reports on Infringements of Patents. All business intrusted to them is done with special care and promptness, on very reasonable terms.

A pamphlet sent free of charge on application containing full information about Patents and how to procure them; directions concerning Trade Marks, Copyrights, Designs, Patents, Appeals, Reissues, Infringements, Assignments, Rejected Cases, Hints on the Sale of Patents, etc.

We also send, *free of charge*, a Synopsis of Foreign Patent Laws showing the cost and method of securing patents in all the principal countries of the world.

MUNN & CO., Solicitors of Patents,
361 Broadway, New York

BRANCH OFFICES.—No. 625 F Street, Washington, D. C.

All the World's Fighting Ships

(NAVAL ENCYCLOPEDIA and YEAR BOOK)

By FRED T. JANE

Author of the Naval War Game (Kriegspiel)

Used as a text-book in European navies. The only absolutely correct and complete work of the kind published

414 PAGES OVER 3,000 ILLUSTRATIONS

OBLONG QUARTO CLOTH PRICE $5 POST FREE

PART I.—THE NAVIES OF THE WORLD: the Great Powers in Order of Strength; the Coast Defense Navies in Geographical Order.

PART II.—ARTICLES ON NAVAL PROGRESS DURING THE LAST TWELVE MONTHS:—With a special article on Warship Engineering by Charles de Grave Sells, M.Inst. C. E.

PART III.—VIEWS AND OPINIONS ON NAVAL QUESTIONS. With a special article by Colonel V. U. Cuniberti, Chief Constructor of the Royal Italian Navy.

PART IV.—SIGNALS AND SILHOUETTES (arranged in the same order as the Navies in Part I.).

Contains:—A photograph of every warship in the world; also a silhouette and a gun and armor diagram of each vessel.

Contains:—The length, beam, draft, horse power, speed, coal supply, number and size of guns, thickness and disposition of armor of each warship in the world.

Contains:—Tables of the size, weight, velocity, energy, penetration etc., of every gun of every navy in the world.

Contains:—A series of chapters by noted Admirals, Naval Constructors, and other experts of various navies, on vital questions of the day in naval construction, tactics and strategy.

Contains:—A comparative table (by the author) of the strength of the navies of the world—the most scientific attempt yet made to classify the world's warships and navies as to actual fighting strength.

It should be noted that this work is from the pen of a naval critic and expert, whose reputation is far-reaching on both sides of the Atlantic. It will be of fascinating interest to those who follow the course of naval development, and as a book of reference should find a place in every library.

MUNN & CO., Publishers

361 Broadway - - - NEW YORK

What Do You Want To Buy?

We can tell you where to buy anything you want.
Write us for the addresses of manufacturers in ANY line of business.
Novelties, Special Tools, Machinery, Equipments,
New Patent LABOR-SAVING DEVICES.

MUNN & CO.

Publishers of the SCIENTIFIC AMERICAN

361 Broadway - - - NEW YORK

ـــــ

ـــ